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capacitación e investigación

INNOVATION, SUSTAINABILITY, AND CRITICAL

PRACTICES IN HIGHER EDUCATION:A MULTIDISCIPLINARY DIALOGUE FROM THE PERSPECTIVE OF EMERGING COUNTRIES



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Innovation, Sustainability, and Critical Practices in Higher Education:
A Multidisciplinary Dialogue from the Perspective of Emerging Countries

Roosevelt Barros Morales
Editor

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Prologue

The vast and complex landscape of higher education, with its many challenges and dynamics, has been profoundly affected by the rapid transformations of the 21st century. In this context, the work we are introducing today emerges as an invaluable testimony to the academic reflection, scientific rigor, and pedagogical commitment of a group of university professors from different latitudes. This compendium, the result of intellectual collaboration that transcends geographical and disciplinary boundaries, not only diagnoses current challenges but also articulates innovative and contextualized proposals to strengthen the quality, relevance, and sustainability of higher education. From a perspective that integrates theory with practice, this book stands as a fundamental tool for academics, educational managers, public policy makers, and, ultimately, for the entire community interested in the future of professional training.

One of the most significant contributions of this compilation lies in its holistic and multidimensional approach. The work avoids the fragmented and technocentric vision so common in discourses on educational innovation, placing the discussions within a framework of interconnected complexity. Rather than limiting themselves to a simple description of digital tools or trendy methodologies, the authors delve into the dialectical relationship between pedagogy and technology, between administrative management and academic quality, and between the university and its social environment. For example, in the articles on new pedagogies and teacher training, there is an insistence on redefining the role of the university professor, who is transitioning from being a mere transmitter of information to a mediator, guide, and facilitator of learning environments. This transformation is not optional, but rather a condition of possibility in an educational ecosystem where students, as central and autonomous actors, demand meaningful and contextualized experiences that reinforce their 21st-century skills, such as critical thinking, creativity, collaboration, and problem solving (Barrientos et al., 2022; Tobón, 2024; Duche-Perez et al., 2024).

The technological dimension is addressed with a critical lucidity that deserves to be highlighted. Far from succumbing to instrumental fascination, the authors analyze Information and Communication Technologies (ICT) and emerging technologies, such as Artificial Intelligence (AI) and the metaverse, from the perspective of their pedagogical potential and ethical implications. A clear consensus emerges: technology is a means, not an end. Its value lies in its ability to enhance learning, personalize the educational experience, and democratize access to knowledge, provided that its implementation is intentional, contextualized, and supported by solid teacher training. There is a justified

warning about the risks of technocracy: digital surveillance, algorithmic opacity, the reproduction of biases, and the widening of the digital divide (Chen & Xie, 2024; Navigli & Rose, 2024). This call for caution is particularly relevant in the Latin American context, where fragile infrastructure and unequal access can turn technology into a factor of exclusion rather than a driver of equity (Agasisti et al., 2023; Maghaydah et al., 2024; Chen et al., 2025).

The work also offers a profound reflection on university management, a topic often relegated to the margins of pedagogical discussion. The various chapters demonstrate that academic quality is inseparable from efficient, transparent administrative management that is aligned with the institution's strategic objectives. Management models in public and private universities are analyzed, highlighting the need to reconcile financial autonomy with accountability, agility in decision-making with democratic participation, and competitiveness with social commitment (Corengia et al., 2024; Illescas Rendón et al., 2025). The digitization of administrative processes and the adoption of data-based governance models are presented as key strategies for modernizing institutions, optimizing the use of resources, and strengthening their responsiveness in a volatile environment (Mego Torres et al., 2024; Villón-Prieto et al., 2025). However, it is emphasized that this modernization must be accompanied by an organizational culture that values innovation, encourages interdepartmental collaboration, and places students and teachers at the center of all decisions (Pincay Quiroz et al., 2025).

A cross-cutting aspect of this work is the emphasis on continuing education for teachers. From training in inclusive methodologies to serve students with disabilities, to training in the ethical use of AI and the adoption of Science, Technology, and Society (CTS) approaches, there is a unanimous conviction: professional development is not a one-time event, but a permanent and indispensable process (Pacheco Lemus et al., 2025; Quiroz-Valdez et al., 2025; Zambrano Mendoza et al., 2025). This idea is based on the notion that only a teacher in constant evolution can prepare new generations for a world in flux. The book proposes training that is not limited to the acquisition of technical skills, but also integrates critical reflection, adaptability, empathy, and social responsibility. In this sense, the work is a call to institutions to invest in their academic teams, providing resources, time, and spaces for collaboration that legitimize and reinforce the work of teachers (Navas Colón et al., 2025; Pacheco Lemus et al., 2025).

The evaluation of learning is another focus of analysis in this collection. The authors dismantle the traditional view of evaluation as a mechanism of control and punishment, proposing instead that it be used as a tool for feedback,

dialogue, and continuous improvement. The various studies argue that mistakes, far from being failures, should be reframed as opportunities for learning and reflection (Schmitt Bernal et al., 2025). Innovations in formative assessment are explored, from the use of digital rubrics and electronic portfolios to automated feedback and learning analytics. These approaches, while promising, require a profound cultural change in both teachers and students to transcend mere measurement and become a catalyst for deep and autonomous learning (Medina-Zuta et al., 2025; Baque Castro et al., 2025). The ability of these tools to generate an "evidence ecology"—a more complete and holistic map of student performance—is presented as a strategic advance for informed pedagogical decision-making (Medina-Zuta et al., 2025).

Finally, this work is part of a broader discussion on the social relevance of higher education. There is a strong commitment to the Sustainable Development Goals (SDGs), particularly SDG 4 on quality education, but also to goals such as gender equality, poverty reduction, and industrial innovation (Chan Fong Solórzano et al., 2025; Pozo Estupiñán et al., 2025). Community outreach projects are presented as key mechanisms for linking university knowledge with the needs of the surrounding community, promoting rural entrepreneurship, public health, and sustainability. Experiences such as the CAIO+ project in Chile or training in bioeconomics in Ecuador show that when universities step outside their walls, they are revitalized and become engines of social transformation, generating relevant knowledge and training professionals with a deep sense of civic responsibility (Marcial Alamilla et al., 2025; Pozo Estupiñán et al., 2025).

In conclusion, this work is an essential compendium for understanding the crossroads of higher education in the contemporary world. Through rigorous analysis and an integrative vision, the authors invite us to transcend superficial debates and address the necessary transformations in the university of the 21st century. The text not only talks about technology and methods, but also reminds us that the essence of education lies in human relationships, dialogue, ethical commitment, and the ability to forge conscious, critical citizens who are committed to building a more just and sustainable future. In short, it is a work that invites us to think, reflect, and, above all, act. It is highly recommended reading for anyone who, from their own position, aspires to contribute to the construction of a more relevant, equitable, and humane higher education system. Its value lies not only in the answers it offers, but also in the questions it raises, inviting us to continue a dialogue that is, by its very nature, infinite and constantly evolving.

Continuing education for university teachers in the management of virtual learning environments

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Introduction

The continuing education of university teachers is a topic of concern for educational researchers that has been widely addressed over time, but in the 21st century, now that its first 25 years have passed, its study has gained greater momentum. This first quarter of a century has seen immense and unstoppable evolution in the development of Information and Communication Technologies (ICT), which, in the case of teachers, today, at any level of education, means that they are not only consumers of these technologies, but also provide answers as to why and how to use that knowledge. This means that they need to move from being consumers to designers of new educational methodologies to enhance critical thinking and interaction with knowledge in students.

These are demands that contemporary scientific and technical development places on the preparation of new generations of human resources to orient themselves and act in a world where science and technology have become a vital element of all human activity. Therefore, teachers have an unavoidable commitment to meeting this demand (Duche et al., 2024).

Today, teachers have the task of keeping their training up to date on an almost daily basis, because new ways of working with technology that benefit the teaching-learning process are constantly emerging. It is a process in which it is recognized that today's students are ahead of most teachers, because they are practically born with mastery of and access to technologies and today demand

different forms of teaching to develop learning on their own. This is not the case for most teachers today.

The need to address the current prominence of students is a statement supported by Paredes, Campoverde, and Játiva (2021) and summarized in the role of the 21st-century student:

- Center and main actor in the teaching-learning process
- Skilled information manager
- Autonomous in the construction of knowledge
- Active in spaces of cooperation and collaboration to achieve meaningful learning through them.

These authors state that "incorporating ICT into the curriculum and into classes requires a new pedagogical model, accompanied by new teaching technologies, learning strategies, and teaching resources." (P.338), which leads to the need for such updated content to be included in the continuing education of teachers.

Therefore, the content of the chapter refers mainly to obtaining information related to the continuing education of university teachers for the management of virtual learning environments (VLE). The aim is thus to contribute in some measure to clarifying concepts, their evolution, and published experiences regarding the management of university environments by teachers.

From this perspective, the literature review involves searches that allow the chapter to address a characterization of the 21st-century teacher in relation to ICT, but with a focus on training. This, in turn, will be described from a conceptual approach that begins with the derivation of the term training, to teacher training, to specify details of continuing education. This approach will allow for an initial understanding of how much this issue has concerned educational researchers. With this starting point, we will proceed to refer to virtual learning environments and finally discuss alternatives for how they should be managed.

This is the starting point for addressing the topic on which this chapter focuses. The authors offer their considerations on the question: what requirements does the continuing education of university teachers have for the management of VLEs? The answer to this question is preceded by reflections on the continuing education of university teachers and the management of VLEs in the university context.

With regard to the continuing education of university teachers, that is, precisely this level of teaching, the aim is for the "novel touch" to the content of the chapter to be the detail that highlights how, indeed, ICTs have transformed education, becoming essential tools for teaching and learning, but with the specificity of the emergence of artificial intelligence (AI), (AI), which marks a new level of evolution within these technologies and will require the inclusion of this content to be prioritized in continuing education.

The reason for this is clear: in this marked "technological evolution," while ICTs facilitate access to information, communication, and the digitization of content, AI provides capabilities for automation, personalization, and advanced data analysis, making it possible to generate educational experiences tailored to the needs of each student.

It is certain that greater attention is needed for the continuing education of university teachers in the development of knowledge with ICT and its link to AI, as described by UNESCO, Echaiz et al. (2021) in their alert to this need.

In order to meet the demand for AI education, universities are offering more AI-related degree programs and online courses. (...) In China, the Ministry of Education approved a program to add AI as a degree specialization at 35 universities. Overall, average enrollment in introductory AI and machine learning courses tripled or quadrupled between 2012 and 2017 at several universities around the world. While there is growing awareness of this issue, more research is needed to understand access to AI training and education, and the current level of human resource availability, especially in relation to developing countries. P.113. (Echaiz et al., 2021)

The quote from Echaiz et al. (2021) highlights the growing need to integrate the teaching of artificial intelligence into university education programs, which highlights the evolution of ICT and its impact on teacher training. The rapid expansion of courses and specializations in AI shows that educational institutions are recognizing its relevance and promoting strategies to train professionals in this area.

However, this effort must transcend the mere offering of programs and be oriented toward deep integration into the continuing education of university teachers, ensuring that they not only update their use of technologies but also understand their pedagogical application and influence on learning.

AI cannot be seen as an isolated complement but as an essential tool that redefines teaching and skills development in a digitized world. Teacher training must move forward with a strategic vision, promoting research that analyzes

access, resource availability, and the real impact of AI on education, especially in contexts where technological gaps still exist. This link between ICT and AI represents both a challenge and an opportunity to ensure a more inclusive, up-to-date higher education that is aligned with the demands of the 21st century.

Theoretical considerations regarding the continuing education of university teachers

The changing characteristics of students and the demand for up-to-date skills require reflection and a rethinking of the teaching role, which is why teacher training faces an unprecedented challenge: to bridge the gap between classroom teaching practice and pedagogical theory, always considering the context in question. Each educational institution must find the training approach that best suits its needs and adopt specific objectives, bearing in mind that the demands of society change over time and require teachers who are adapted to the needs of the moment.

To explore the subject in greater depth, we must first consider the details of the term "training."

The term training: a starting point for analysis

Etymologically, the term training comes from the Latin *formativo* and refers to "forming something." In education, training is what a person obtains throughout their studies and life; that is, a person becomes an excellent professional as a result of the good training they have received. Gutiérres (n.d.). Gutiérres' (n.d.) criterion is based on the fact that, in today's society, learning and training have become a constant necessity in order to remain up-to-date and competitive in both personal and professional spheres. Training offers numerous benefits, from improving skills and competencies to greater employability and job satisfaction. The aforementioned author notes that:

Training refers to the process of acquiring knowledge, skills, and competencies through different methods or means. It can be carried out formally or informally, in different environments such as academic, professional, or personal. The main objective of training is personal and professional growth and development. Gutiérres, P. (n.d.)

From his perspective, Manzanares (2012) considers that teacher training is an indispensable and continuous process, essential for their professional growth and development, to keep them up to date and competitive. In this regard, González (2021) views it as a process aimed at achieving specific results in the individual, that is, it focuses on the impact it has on the individual's development.

Although it is often associated with certificates or documents that accredit its completion, its meaning goes far beyond the superficial.

Based on these arguments, it is worth mentioning Imbernón's (2005) criterion because he associates it with professional development, considering it a process that begins with the choice of a specific discipline, trade, or profession, and whose mastery of knowledge, skills, and competencies is gradually perfected through continuous or ongoing training. Imbernón (2024) argues that the subject has not achieved the level of importance given to it in other professions that require constant updating, considering it a means of professional development and improvement.

The authors consulted focus their criteria on the fact that the category of training can be understood as a process. However, it is important to note that viewing it solely as a process represents a reductionist approach because it should not only be conceived as a process but also as a result. It should be noted that, as a process, it must include a system of actions and influences aimed at fostering diverse knowledge, skills, values, and personal competencies. As a result, its transformative nature is manifested in the fruits of the process, materializing a fulfilled desire. In other words, at the end of the process—or at some point during it—an assessment must be made of the extent to which the teacher has managed to positively change the initial state and has advanced to the desired state. This approach necessarily leads to thinking about the existence of a plan for the continuous training of university teachers, which, through established deadlines, is subject to evaluations that identify progress, delays, or difficulties in this regard.

Although the concept of training has been addressed, it is worth mentioning some basic ideas related to the continuous training of teachers. Globally, it is conceptualized under various names, which vary according to the geographical and disciplinary context and the theoretical framework adopted by different authors.

Continuing education for teachers

Continuing education can be understood as a comprehensive development process that involves multiple facets of people's lives, including personal, work, family, professional, and social aspects. This process requires commitment, perseverance, willpower, dedication, and responsibility. In addition, it facilitates the satisfaction of the training, work, and updating requirements that professional contexts impose on specialists. At the same time, new approaches must be considered that promote the evolution from a traditional teaching-

centered approach to a training approach in which learning is the priority. (Ochoa et al., 2016)

Continuing education for teachers as a concept requires first clarifying what is meant by teacher training, which must undoubtedly be aligned with the needs of the specific education system in question, responding to the demands of its context and ensuring that teachers are able to design, plan, and evaluate teaching and learning processes effectively. It is essential to consider the preparation of these professionals so that continuing education can provide them with the tools to respond to the demands of the school context and, in addition, stimulate quality education. (Villamar, 2025)

Given that, according to Chávez (2019): the intention of continuous preparation and updating for teachers arises from the need to establish quality in teaching through effective teaching practice, the concept of teacher training is difficult to define precisely, given the multiple dimensions and perspectives of the teaching task in the context of universities, as well as the dynamic evolution of the roles of teachers in the changing scenarios of the 21st century.

However, even with the diversity of definitions that exist, it can be understood that teacher training has to do with all those activities that teachers follow or have at their disposal to improve their knowledge, skills, and behaviors as teachers and educators, researchers, in individual and group settings.

Continuing teacher training should be guided by internal policies defined by educational institutions, giving prominence to their teachers, who, based on their own practice, identify the needs of society and the environment and establish the guidelines and actions that guide training plans, based on a contextualized view of the teacher's own learning process. It is part of the responsibility of educational institutions to manage this important process.

Thanks to the efforts of individual initiatives, universities, and international institutions such as UNESCO, there is growing interest in sharing learning resources openly and free of charge via the internet. (Maina, et al., 2015)

Based on advances in science, technology, and society, as well as the effect of factors unrelated to education, such as the COVID-19 pandemic, it became necessary to make use of virtual classroom technology at different levels of education (Rodríguez et al., 2022). One such technology is virtual learning environments, which, although not a recent phenomenon, have been exploited more intensively since that historic moment.

We agree with Balarezo et al. (2024), who have stated that, at the present time, VLEs have profoundly transformed contemporary education, based on the rapid development of digital technology and the need to adapt educational processes to the demands of a globalized world. These authors conceptualize it as "the integration of technological platforms and tools designed to facilitate the teaching and learning process asynchronously or synchronously, using the internet as the main channel" (p. 63).

In general, the content of this section once again highlights the current value of continuing education for university teachers in higher education. This is because it is always a fundamental axis in the evolution and transformation of the educational system. It is a permanent requirement that guarantees the updating of teachers, equipping them with the ability to respond to the demands of a constantly changing society.

As a dynamic process, the continuing education of university teachers involves not only the improvement of knowledge and skills, but also the transformation of pedagogical approaches that prioritize active learning and, in these times of the 21st century, the integration of emerging technologies.

In this sense, the inclusion of ICT has led to a rethinking of the role of the teacher. The literature consulted shows that training should be understood both as a process of development and as a tangible result, reflected in the quality of teaching and the impact on students. It is imperative that educational institutions adopt flexible training models that are contextualized and aligned with the needs of teachers, fostering spaces for collaborative learning and the generation of meaningful knowledge. In short, continuing education not only improves teaching practice, but also strengthens the professional commitment and comprehensive development of educators, consolidating a higher education system that is more relevant, innovative, and capable of facing the challenges of the 21st century. To achieve these imperatives, teachers need to learn how to manage virtual learning environments in higher education, an aspect that is addressed in the following lines.

The management of virtual learning environments in higher education

The title of this section contains two important points in this part of the chapter: the analysis of the evolution of this thinking from the first five years of the 21st century to the present day. And some details about the concept of VLEs in relation to their management.

With regard to the first point, which refers to a look at the evolution of thinking related to virtual learning environments, it includes arguments organized around

the ideas of Salinas (2005), Giordan and Gois (2009), and Montagud and Gandía (2014) to begin with. In the case of Salinas (2005), his overview of the range of possible uses that can be achieved in the field of distance education stands out, until he accurately describes a virtual learning environment as a space or community organized for the purpose of achieving the learning required of certain components:

- a pedagogical function (learning activities, teaching situations, learning materials, support and tutoring, assessment, etc.),
- appropriate technology (tools selected in connection with the pedagogical model), and
- organizational aspects (the organization of space, the calendar, community management, etc.).

Salinas (2005) views pedagogical management as a process of educational innovation based on the teacher creating the conditions for developing the ability to learn and adapt.

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Agile Methodologies in Educational Transformation: New Perspectives on Creativity, Motivation, and Performance in Digital Teaching

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Introduction

Digital transformation has reshaped higher education, accelerating the need to rethink traditional pedagogical models. Beyond merely incorporating technology, digitalization demands a redesign of teaching practices to foster autonomous, critical, and creative learners (Barrientos *et al.*, 2022; Castañeda & Cuéllar, 2020).

From a social constructivist view, learning is an active and contextual process built through social interaction and problem-solving. Thus, methodologies must support participatory, flexible environments that encourage collaboration and reflection (Ocampo, 2022; Ramírez-Montoya, 2020).

Originally from software development, agile methodologies have gained traction in education for promoting active learning, adaptability, and classroom innovation (Pimonova, 2020; Vera *et al.*, 2021). Notably, Design Thinking, Scrum, and Lean Startup stand out for their emphasis on empathy, experimentation, and collaborative idea validation (Arzuaga Mejía, 2025; Brown, 2009).

Aligned with Kolb's (1984) experiential learning model, these approaches support learning-by-doing cycles where students generate solutions, receive feedback, and reflect. Likewise, Fullan and Langworthy (2014) highlight that innovation must prioritize 21st-century skills—creativity, communication, collaboration, and critical thinking.

This study analyzes the impact of these methodologies in virtual university teaching, focusing on motivation, creativity, interactivity, and academic performance. It rests on the assumption that agile practices foster dynamic, iterative, and student-centered learning environments (Pozuelo, 2020; Dugarte Mendoza *et al.*, 2023).

Empirical evidence in virtual contexts is needed to rethink the teacher's role, assessment modes, and knowledge construction (García-Mendoza & Vera-García, 2022; Díaz Barriga-Arceo & Barrón-Tirado, 2020). This research views

educational transformation as a systemic process integrating technology, pedagogy, and institutional culture (Almea Veliz *et al.*, 2024).

Ultimately, the study offers theoretical and practical insights for incorporating agile methodologies as innovation tools that enhance learning and prepare students for dynamic and collaborative professional settings.

Case Study

This research is framed within the transformation of higher education in response to the challenges of digitalization and pedagogical innovation. In recent years, universities have had to rethink their teaching practices due to technological progress, the expansion of virtual education, and the need to train professionals suited for dynamic, collaborative, and evolving environments. Agile methodologies have emerged as an effective pedagogical strategy to foster active learning, creativity, teamwork, and autonomy.

The study was conducted in private Colombian universities that, over the past three years, have advanced in digital transformation and virtual education. The analyzed programs are fully online, enabling structured integration of educational technologies and active, student-centered methods. These institutions have incorporated Design Thinking, Scrum, and Lean Startup to improve educational quality in digital contexts.

Originally created in business and technology sectors, these methodologies have been adapted to education to support project-based learning, problem-solving, and the development of transversal 21st-century skills. The convergence of innovation and virtual teaching has created new learning dynamics worth exploring from empirical and reflective perspectives.

The sample included faculty and students actively engaged in innovation processes. The participating institutions apply agile methodologies both in theoretical and practical courses to boost engagement, creative thinking, and collaborative problem-solving.

This context reflects a strong commitment to pedagogical modernization. Teaching is no longer limited to content delivery but conceived as shared knowledge construction. Understanding how agile methodologies are perceived and implemented offers valuable insights to design more effective, sustainable, and student-centered educational strategies.

The findings of this study provide a comprehensive understanding of the impact of agile methodologies—Design Thinking, Scrum, and Lean Startup—on higher education learning environments. Through a mixed-methods approach, key

dimensions of the teaching-learning process were explored, including student motivation, academic performance, interactivity, satisfaction, and creativity. Quantitative results were gathered through surveys administered to 150 students, while qualitative insights were obtained via interviews with faculty and students.

Overall performance across key variables

Descriptive analysis revealed a generally positive perception of agile methodologies among students. High mean scores were observed for the variables' motivation (M = 4.20) and creativity (M = 4.25), and all evaluated variables exceeded an average value of 3.8, indicating a high perceived effectiveness from the students' perspective. It is important to note that a five-point Likert scale was used (1 = strongly disagree and 5 = strongly agree), which provides a clearer context and meaning to the reported statistical values. Table 1 presents the descriptive statistics corresponding to the five key variables evaluated in the study. It includes the means, standard deviations, and response ranges observed using the Likert scale applied.

Table 1. *Descriptive Statistics for Key Variables*

Variable	Mean	Std. Deviation	Range (Min–Max)
Motivation	4.20	0.75	2.5 – 5.0
Academic performance	3.80	0.85	2.3 – 4.8
Satisfaction with agile methodologies	4.10	0.78	2.9 – 5.0
Learning interactivity	4.05	0.80	3.2 – 5.0
Creativity	4.25	0.70	3.4 – 5.0

Students particularly valued the creativity stimulated by Design Thinking and the Lean Startup approach, as reflected in the highest average score recorded for the creativity variable (M = 4.25; SD = 0.70). Likewise, interactivity—an essential trait of agile methodologies—received an average score of 4.05 (SD = 0.80), highlighting its role in fostering meaningful and participatory learning environments.

Correlations between key variables

Pearson correlation analysis indicated statistically significant positive associations among all variables. Motivation correlated strongly with satisfaction (r=0.72), interactivity (r=0.70), and creativity (r=0.68). Additionally, academic

performance showed moderate correlations with motivation (r = 0.65) and creativity (r = 0.62). Table 2 summarizes the Pearson correlations among the main variables of the study. The coefficients show statistically significant associations between motivation, performance, satisfaction, interactivity, and creativity.

Table 2. *Pearson Correlations among Key Variables*

Variable	Motivation	Performance	Satisfaction	Interactivity	Creativity
Motivation	1	0.65**	0.72**	0.70**	0.68**
Performance		1	0.56*	0.60**	0.62**
Satisfaction			1	0.75**	0.69**
Interactivity				1	0.66**
Creativity					1

Note: p<0.05 (*), p<0.01 (**)

These results confirm that agile methodologies not only enhance student engagement but also contribute to a more satisfying, creative, and effective learning experience.

Comparison between agile methodologies (ANOVA)

To assess whether significant differences existed in motivation levels among methodologies, a one-way ANOVA was conducted. Results indicated significant differences (p = 0.003), with Design Thinking yielding the highest motivation scores. Table 3 presents the results of the analysis of variance (ANOVA), used to compare motivation levels among the applied agile methodologies. The analysis reveals statistically significant differences, with Design Thinking showing the highest motivation scores.

Table 3. *ANOVA: Motivation by Agile Methodology*

Methodology	N	Mean	Std. Dev.
Design Thinking	50	4.45	0.65
Scrum	50	4.10	0.75
Lean Startup	50	3.80	0.85
Total	150	4.11	0.78

F=5.87, p=0.003

These results suggest that student-centered methodologies such as Design Thinking significantly enhance motivation, likely due to their focus on creative problem-solving and user empathy.

Qualitative findings: perceptions and experiences

The qualitative dimension of the study provided more profound insights into the experiences of students and faculty with each methodology. The matrix below summarizes the most salient themes by category and methodology.

Table 4 summarizes the qualitative findings obtained from the interviews, organized by category and methodology. It presents the most representative perceptions related to adaptation, creativity, satisfaction, interactivity, and the development of soft skills.

Table 4. *Qualitative Findings Matrix*

Category	Design Thinking	Scrum	Lean Startup
Student adaptation	High initial motivation, some resistance due to novelty	Gradual adaptation; some frustration with rigid structure	Quick adaptation; some find it too technical
Perception of creativity	Very positive, especially during ideation and prototyping phases	Less focused on creativity, more on task organization	Strong creativity, especially in rapid prototyping and testing
Overall satisfaction	High satisfaction, especially during idea development	Moderate satisfaction; complexity in early stages	High satisfaction with the idea validation stages
Learning interactivity	High interactivity; group work is well-received	Moderate, focused on planning meetings	High emphasis on collaboration and hands-on experimentation
Development of soft skills	Encourages problem-solving, critical thinking, and collaboration	Promotes self-management and decision-making	Enhances entrepreneurial skills and adaptability

The interviews revealed that Design Thinking and Lean Startup provided the most stimulating learning environments, fostering greater creativity and satisfaction. Scrum, although effective for project organization, was perceived as less flexible and more challenging to implement in early stages.

Cluster analysis

This study provides an integrated view of the pedagogical impact of agile methodologies—Design Thinking, Scrum, and Lean Startup—in university-level virtual education, using a mixed-methods approach. Surveys of 150 students revealed high levels of motivation (M = 4.20), creativity (M = 4.25), and

satisfaction (M = 4.10), with all variables scoring above 3.8 on a five-point Likert scale. Correlation analysis showed significant relationships among variables. Motivation was strongly linked to satisfaction (r = 0.72) and interactivity (r = 0.70), while interactivity and creativity were also positively associated (r = 0.66), reinforcing the idea that collaborative environments promote enriching learning experiences.

ANOVA results confirmed significant differences in motivation across methodologies (p = 0.003), with Design Thinking achieving the highest mean score (M = 4.45), followed by Scrum (M = 4.10) and Lean Startup (M = 3.80). This highlights the motivational power of methodologies focused on empathy and creative problem-solving. Qualitative interviews supported these findings. Students valued the practical and collaborative nature of Design Thinking and Lean Startup. While Scrum was helpful for structuring tasks, it posed initial adaptation challenges. Agile methodologies were also perceived to enhance transversal skills such as self-management, critical thinking, and decision-making—essential for today's professional demands. These results align with Kolb's (1984) experiential learning model and Fullan and Langworthy's (2014) emphasis on 21st-century skills like creativity and collaboration. They also confirm the relevance of agile frameworks in virtual education, as noted by Vera-Sagredo *et al*. (2021), Pimonova (2020), and Ramírez-Montoya (2020), who underline their potential to foster autonomy, innovation, and engagement in digitally mediated learning environments.

Conclusions

The results of this study demonstrate that integrating agile methodologies in higher education has a positive impact on key dimensions of the teaching-learning process, including motivation, academic performance, interactivity, creativity, and student satisfaction. These methodologies not only revitalize pedagogical practices but also enhance student agency by fostering more active, collaborative learning environments that support the development of adaptability, innovation, and problem-solving competencies required in contemporary knowledge-based societies.

In particular, Design Thinking stood out as the methodology most capable of enhancing student motivation and creativity. At the same time, Lean Startup was praised for encouraging experimentation and the practical validation of ideas. Scrum, on the other hand, proved helpful in project organization, although it required a more extended initial adaptation period for some students. From a practical standpoint, these findings offer a solid foundation for higher education institutions to rethink their pedagogical models. Faculty training, curricular flexibility, and the use of collaborative virtual environments are key factors for

the successful implementation of these methodologies. Furthermore, this research contributes to the growing body of knowledge on the transformative potential of agile approaches in education, offering guidance for future innovation strategies in university teaching.

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Uses of Artificial Intelligence in Educational Research by graduate students

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Introduction

The content of this paper is based on the need to gain a comprehensive understanding of the use of artificial intelligence (AI) for educational research by teachers who are actively engaged in continuing professional development in the field of applied AI.

The literature review aims to provide a systematic presentation of findings on topics such as the uses, perceptions, and ethical challenges of AI in educational research by teachers. In each case, the search focuses on identifying the most widely used tools, attitudes toward their implementation, and concerns related to originality, confidence in results, and institutional regulation.

To meet the research needs outlined in the paper, we first provide a general description of the three theoretical references that make up the title of this chapter. That is, AI in education in the 21st century, educational research in its link with AI in these times; and both references, appreciated in the continuing education of teachers through postgraduate studies, in an attempt to clarify the state of the art regarding how institutions meet the needs of teachers regarding the use of AI for educational research.

With regard to the link between AI and educational research, the aim is to present the current state of two levels of management: teaching and institutional. Within the latter, the responsibility of the institution for the

necessary satisfaction of the needs of teaching work with AI in educational research and issues related to the existence or otherwise of possible regulation in this regard.

This last issue within institutional responsibility opens the door to reflection on the extent to which regulations are necessary in the first place and, furthermore, whether it would be better to appeal to proper and up-to-date teacher training so that good practices with ethical attitudes and values emerge during the research process when using AI. On both levels, the aim is to describe the uses of AI for educational research, the concerns and challenges to be addressed, training guarantees, regulations, and infrastructure (Barros and Sierra 2025).

With this perspective, the chapter aims to analyze the impact and evolution of artificial intelligence in higher education during the 21st century, identifying the main tools used in educational research, as well as their advantages and challenges in terms of access to information, originality, and reliability in scientific production.

To achieve this, we intend to develop a systematic review of the literature published in the last 5 to 10 years, applying a qualitative, bibliographic methodology at an exploratory level, which will shed light on the concerns and occupations of the actors at the level of teachers and institution managers, in order to obtain solutions that favor the relationship between AI and educational research.

The evolution of AI and its impact on higher education

The origins of AI can be traced back to the 1950s, when there was a need to find answers to how to build machines that could mimic human intelligence. The findings of scientists such as John McCarthy and Alan Turing were the first answers that are now part of the history of AI. Alan Turing's contributions referred to the concept of the "Turing Machine," an abstract model that formalizes the computing process, and the "Turing Test," as a way to assess whether a machine can exhibit intelligent behavior that is distinguishable or indistinguishable from that of a human. McCarthy formalized AI as an academic discipline, coining the term during the first conference on the subject at Dartmouth in 1956. That conference was organized by McCarthy and is considered the formal beginning of the field of AI. (Baños-González, 2024)

The applications of AI to education came about thanks to Donald Bitzer in the 1960s, with the creation of one of the first educational projects to use it: the so-called "PLATO." A computer-based teaching system. PLATO used a

combination of graphics and text to teach a variety of subjects, from mathematics and science to languages and art. (Fernández de Silva, 2023)

The researcher notes that over time, intelligent tutoring systems were developed (computer programs designed to provide students with adaptive, personalized, real-time feedback). One of the first intelligent tutoring systems was "ASK" (Automated Study Guide), developed by John Anderson and Albert Corbett in the 1980s.

Since then, the list has become endless and continues to grow with an unstoppable momentum of possibilities, alternatives, and challenges. It is clear to everyone that, since its emergence, AI has been influencing the way we teach and learn, addressing the needs and interests of students at an individual, personalized level.

The personalization of learning is one of the main opportunities offered by AI, because it offers students the opportunity to actively participate in the choice of educational content and search strategies according to their specific needs (Jiménez-García et al., 2024). Personalized information, assessment, and feedback during learning are indicators that reflect a significant improvement in student performance and motivation.

For example, in the 2000s and 2010s, artificial intelligence reached an unprecedented peak with technologies such as cloud computing and deep learning. The latter, with its potential to aid in the training of algorithms capable of pattern recognition and autonomous learning, has led to significant advances in areas such as image recognition, natural language processing, and robotics. (Fernández de Silva, 2023). This led to the emergence of a variety of educational applications, such as learning data analysis to improve educational decision-making, the creation of personalized educational materials, impact through the creation and sharing of content, videos, presentations, and images, and the possibility of identifying learning problems.

It can be seen that AI has had a transformative influence on education since its inception by providing more personalized, accessible, and effective learning for all students, and this is a recognized trend today. Over the past two decades, a significant amount of research has been conducted on the applications of artificial intelligence (AI) in education. These include intelligent tutoring systems, adaptive teaching and learning, assessment design, and learning analysis in higher education (Área-Moreira et al., 2024). And we must not forget the push for application and the necessary and urgent learning process (especially on the part of teachers) that all these results received during the COVID-19 pandemic.

With such arguments, it can be said with certainty that, in the 21st century, AI in education is one of the innovations that promise a beneficial future for education, as there are tools, virtual assistants, and platforms that favor student participation, with the teacher acting as a guide and creating learning situations and environments that place students at the center of attention.

In this sense, the relationship between the form of teacher participation and the benefit of the student being the center of attention, based on theories such as Piaget's psychological development, Ausubel's meaningful learning, Bruner's discovery learning, and Vygotsky's sociocultural theory, which contribute to a restructuring of the student's cognitive system to make them the center and main actor in the learning process and a skilled information manager. (Paredes, Campoverde, & Játiva, 2021).

All of this reveals the contributions of constructivist theory, in which students take on new leading roles in a new technology-based pedagogical paradigm, giving way to a new way of learning in which teachers guide the teaching process, thus establishing countless opportunities to develop educational research in response to the need to understand educational processes and make informed decisions, now, above all, based on possibilities for personalization, for example.

But the challenge now lies with the teacher, because today's students were practically born with AI technology at their fingertips, but most teachers have not yet appropriated this knowledge and its benefits. This results, at best, in a lack of use of AI possibilities and a strong presence of the traditional view of the teaching-learning process, and at worst, in an attitude of resistance to change and a fear that ignorance will reduce their cultural prestige in the institution. This is what Argüello (2025) means when he says: “The future is already here, but the past is not yet gone.”

Artificial intelligence in higher education: the link with educational research

The advancement of AI has transformed multiple sectors, including higher education and academic research. From this perspective, it is necessary to highlight the link between AI and educational research because, from a general scientific point of view, as pointed out by Diaz (2024), it fosters innovation and raises the quality and application of results focused on solving social, environmental, and geopolitical problems, among others related to education, mainly because knowledge of the different AI tools:

facilitates different research processes, reduces the time and cost of studies, and produces greater impact by enabling macro studies with large amounts of data. Likewise, aspects such as the theoretical inquiry required in academic research become much more efficient and rapid through AI. (p.257) Díaz (2024).

Some examples of possibilities in education to consider are recognized by Medina (2024), including: teachers can better understand how AI can be used to improve teaching and learning, teachers can provide practical recommendations for the implementation of AI in higher education, and they can also contribute to the creation of new learning models and thus foster innovation in higher education.

Fernández de Silva (2023) also highlights some examples of how solutions to problems in different areas of educational research have been addressed with AI:

1. Intelligent Tutoring and Adaptive Learning Systems:

    - Creation of intelligent tutoring systems that simulate student thinking and provide personalized feedback.
    - Application of human cognition theory to the development of intelligent control systems adapted to individual learning.
    - Development of intelligent instruction systems that can be adjusted to individual learning needs.
    - Use of virtual and augmented reality technologies in education to improve intelligent tutoring and student comprehension.

2. Data Analysis and Predictive Modeling

    - Building predictive models of student academic success and personalized feedback.
    - Data analysis and data mining to discover learning patterns and adapt teaching.

3. Innovations in Assessment and Feedback

    - Improving online student feedback and assessment.

4. Impact of AI on Education and Ethical Reflection

    - Exploration of the importance of not relying too heavily on technology and ensuring a human-centered educational process.

- Concerns about artificial intelligence and its impact on society and education, with a focus on learning, needs, and skills of students and teachers.

5. Development of Intelligent Educational Resources

- Creation of more effective, accessible, and personalized learning technologies for each student.
- Development of a recommendation system for language learning and AI educational resources.

These results coincide with Fadlelmula & Qadhi (2024) regarding how AI has been used in various educational applications. Some of these include intelligent tutoring systems, adaptive learning, and educational data analysis.

The implementation of research results and uses of AI in scientific production undoubtedly reveals important opportunities, but also challenges, generating debates about its use and the ethical implications in the generation of knowledge (Loján et al., 2024). In the context of postgraduate education, when developing educational research, the use of AI tools raises questions about research training and the academic responsibility of this type of training in the management of these technologies (Borja et al., 2025).

Therefore, at the time of writing this chapter, the benefits, challenges, and concerns are understood as perceptions on the part of those involved in the educational process, and their solution can be achieved through continuing education at the postgraduate level.

Continuing education and the role of postgraduate studies in integrating AI into educational research

In the 21st century, the development of higher education requires the ethical integration of AI, with a special focus on educational research, avoiding the uncritical automation of knowledge and strengthening the critical thinking of researchers (Rojas Betancur & Méndez Villamizar, 2017). In this sense, academic institutions can contribute with positive attitudes and appropriate practices while fulfilling their mission with regard to the use of AI.

The most widespread idea is that academic institutions play a key role in regulating the use of AI, establishing clear guidelines for its application in research and promoting good practices in the generation of knowledge (González, 2018). This is particularly evident because, in recent years, growing knowledge about its applications has placed AI at the center of university

debates globally, addressing issues such as academic integrity, curricular adjustments, and other aspects of the learning experience (Vera, 2023).

Among the most relevant challenges of AI in education in its link to educational research, ethical issues stand out. Vera (2023) points out key aspects such as privacy versus surveillance, bias versus discrimination, and philosophical concerns about the role of human judgment. However, a topic less addressed in the literature is plagiarism derived from the use of AI. In this regard, Solís Peña et al. (2025) emphasize that, although information technologies can complement learning and facilitate interaction between students and teachers, they also have disadvantages such as the spread of unreliable information, incomplete learning, and the possible encouragement of academic plagiarism.

This concern is also shared by Gallent Torres et al. (2023), who warn about incomplete or false content that can mislead researchers, teachers, and students in their academic work. In addition, Cotton et al. (2023) highlight the emergence of new forms of plagiarism and academic fraud, impersonation of authorship, lack of transparency in the generation of information, and other risks inherent in the use of AI.

It is recognized that AI in universities affects teaching, learning, the teaching-learning process, educational management, and research itself. With regard to the latter, López et al. (2024) highlight that generative AI tools are having a huge impact on education and research because they are capable of generating text, images, video, music, programming codes, among others. However, these researchers clarify that the process of researching and writing a scientific article must be guided and supervised by expert human researchers who guarantee the accuracy, consistency, and credibility of the content.

As expressed in the previous paragraphs, the virtues and concerns of using AI in education, and especially for educational research, are a cause for great concern. One alternative for, first of all, educating and updating teachers on AI so that they can use it ethically in educational research is postgraduate study. This provides a space for strengthening knowledge and research skills, now with the effective use of technological resources.

Participation in postgraduate programs with the production of research in education, the training that postgraduate students receive, and the use and impact of educational research in postgraduate programs are examples of ways in which, in the 21st century, AI is irrevocably and positively intertwined with educational research.

Postgraduate studies are a training space to respond to the need for teachers to update their skills in light of the rapid changes brought about by globalization, technological advances, and the current circumstances facing higher education. This training space guarantees the promotion and development of research skills in teachers, as part of continuing professional development, to strengthen university education.

Higher education has a responsibility to ensure the development of teachers' professional and research skills through training, taking into account the objectives of the knowledge society through scientific research and redefining the role of the teacher as a researcher (Moreno, 2021).

Postgraduate training is undoubtedly a fundamental part of institutional strategies for training in AI applied to educational research.

Teachers in continuing education through postgraduate studies have a responsibility to keep their training up to date in order to adapt learning strategies to tasks that foster the development of creative capacity, problem solving, and decision making, taking advantage of opportunities for personalized learning. This means that students learn to generate new knowledge by interacting with AI tools according to their own characteristics (Hernández, 2023). However, teachers need training so that they can apply this to their tasks in the teaching-learning process and in educational research.

Certainly, AI and all its benefits for streamlining and improving the quality of educational research processes are indisputable, but users must be taught to ask the right questions and, more importantly, to communicate effectively with the resources and tools that AI makes available for research. As Hernández (2023) asserts:

It is important to bear in mind that the information generated by these tools may be biased. Not all the answers provided by Generative AI (GIA) are 100% real or true, as this depends on how the information instructions are set. It is not enough to ask general questions or use keywords, as this could limit the information generated. Therefore, the use of prompts or instructions is essential to obtain more accurate and higher quality answers. The more precise, defined, and detailed the instruction provided to the tool, the better the quality of the information generated and the more effective the conversation with the GAI will be. (p.17) (Hernández, 2023)

However, the instructions contained in the prompts are not enough if the teacher does not have the skills to ask questions, observe, reflect, and make proposals. Imagination and creativity are required to converse with AI robotic actors. It is

not a matter of addressing Chat GPT or another resource and telling it what is needed. These tools are designed to establish a conversation that allows the user to describe and exemplify their interests while demonstrating knowledge of what they seek to deepen, expand, and investigate. These are essential skills for teachers to work with technologies and even improve their interpersonal and communication skills.

In Latin America, a multitude of master's programs in education are being developed. A quick review of the literature on the internet of the different communications, calls, and socialization of postgraduate programs in this regard reveals a variety of names for these programs. The names of these programs highlight the use of references to AI applied to educational research. Countries such as Peru, Ecuador, Chile, Colombia, Brazil, Argentina, Honduras, and Mexico are examples of this, according to Huarcaya (2022).

Teaching and institutional management in the use of AI for research

Management is understood as the system of strategic and planned activities that are carried out guided by appropriate instructions and techniques to achieve certain ends or goals. These ends, goals, or objectives can be achieved by individuals, institutions, and both public and private companies (Gutiérrez, 2020). In search of a derivation of this concept towards that of teaching management in the interests of this chapter, we can affirm with Altablero (2007) how responsible management goes through moments of diagnosis, planning, execution, monitoring, and evaluation, with data that feed into each other and lead to the achievement of the results defined by the management teams. Thus, institutional management, aimed at the quality of teacher training in research skills, using AI for educational research, must include studies comprising the aforementioned stages in order to ensure that teachers are up to date in this area. Similarly, teachers have a responsibility to prepare themselves and avoid resistance to change with regard to the use of AI in their educational and research processes, as the use of AI brings benefits of incalculable value. Showing a willingness to change and to undergo updated training are attitudes that are reflected in the proper performance of their duties when they show expectations and ways of acting towards increasing their knowledge, achievements, and desire for harmony. Regarding the use of AI by graduate students (specialization, master's, and doctoral), Aguirre et al. (2024) emphasize that the use of AI-related applications does not depend solely on access to them, but also on students' attitudes toward their use in educational processes and for the development of research skills.

Infrastructure and training guarantees for the ethical use of AI

Institutional responsibilities lie not only in organizing training strategies to update teachers' skills, but also in guaranteeing the equipment, internal logistics, and infrastructure required for the proper implementation of AI in educational institutions, which in turn respond to the development of educational research. At the higher level, in postgraduate programs, institutions have incorporated the use of technological resources based on an infrastructure that provides their university students with Internet access, educational platforms, and computer equipment. For example, it is already known that there are devices, connectivity, and AI platforms adapted to different educational levels, as well as training and technical assistance mechanisms that allow for the proper maintenance of the infrastructure and its optimal use, as well as the promotion of ecological practices in the development and implementation of technologies, such as the use of energy-efficient servers or the recycling of technological equipment.

Perspectives on the need for regulations or regulation in the use of AI for educational research

The implementation of artificial intelligence in education offers numerous opportunities to improve the teaching and learning process through personalized learning, automated assessment, and intelligent tutoring (Inca, et al., 2024). Significant benefits are also observed in educational research in terms of opportunities for knowledge generation, data analysis, and the optimization of academic processes. However, with regard to its implementation, all eyes are on the opinion that, without clear regulations, it can lead to risks associated with privacy, equity, and transparency of the results obtained. Therefore, the majority opinion is that it is essential to develop regulations and policies that establish guidelines on the use of AI in this field, ensuring an ethical, inclusive approach based on principles of educational justice. The concerns of (Inca, et al., 2024) revolve around the collection and use of large amounts of student data and the protection of privacy and the security of personal information. Another risk is that the implementation of AI could widen existing inequalities if equitable access to these technologies is not ensured. This highlights the importance of inclusive policies that guarantee that all communities, regardless of their location or resources, have equitable access to AI tools.

Concerns about plagiarism and indiscriminate copying are being addressed, some more severely than others, and some are already well known with the existence of anti-plagiarism tools. Academic plagiarism represents an ethical challenge for those who write documents. This practice undermines the principles of honesty, integrity, effort, and respect for the work of others, which are fundamental to academic training. This is recognized by (Rodríguez, 2023).

However, many countries are calling for the existence of Principles on AI that address people's interests, guarantees of transparency such as accountability in the development and deployment of AI, regulation, biases, among other aspects associated with the risks, ethics, and security of systems. In Latin America in particular, there is a clear trend in proposed legislation toward the adoption of a risk-based approach, among other provisions. (Ulloa, 2024) This is what Filgueiras (2023) describes as strategies for artificial intelligence in Latin America defining modes of governance that expect ethical behavior from developers and broad development objectives without specifying the mechanisms by which development will be carried out. They focus on AI ethics without being accompanied by adequate policy instruments to achieve development objectives.

Conclusions

The analysis developed in this chapter shows that artificial intelligence (AI) has established itself as a key tool in higher education and educational research, with a significant impact on the production of and access to knowledge. Its incorporation has enabled advances in the personalization of learning, the automation of assessments, and the development of intelligent tutoring, which favors the quality and efficiency of academic processes. However, it is clear that the use of AI in educational research is not without challenges and concerns. The literature review shows that teachers and researchers have expressed concerns about the reliability of AI-generated data, the possible reproduction of biases, and the growing threat of misinformation and academic plagiarism. In this regard, the importance of continuing education for teachers, especially at the postgraduate level, is highlighted as a fundamental mechanism for ensuring the ethical and critical use of these technologies.

Another central aspect of the analysis is the need for adequate infrastructure and institutional policies to regulate the use of AI in research. Technological accessibility, technical support, and system sustainability are essential conditions for its effective implementation in higher education. Likewise, the development of regulations that define ethical principles and clear rules is positioned as an essential strategy to avoid risks associated with privacy, equity, and transparency in research processes.

In Latin America, the evolution of AI regulations follows a risk-based approach, seeking to ensure its responsible development without compromising the fundamental values of education and knowledge generation. Despite the advances identified, challenges remain in defining clear standards to guide the use of AI in education, reinforcing the need to establish more robust governance frameworks.

The integration of AI into higher education and educational research definitely requires strategic planning that combines technological innovation with ethical principles and regulatory policies. Institutions must take an active role in teacher training and the promotion of good practices, ensuring that AI becomes an ally of learning without compromising academic integrity or the quality of scientific production. Teachers, for their part, have a dual responsibility: to undergo continuous, up-to-date training and to apply their knowledge of AI, its resources, tools, and ethical principles to the teaching process in such a way that students can construct their own knowledge under the guidance of the teacher.

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Nutrigenomics and Nutrigenetics, implications for cardiovascular risk prevention

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Introduction

Cardiovascular diseases (CVD) are the leading cause of death worldwide; ischemic heart disease accounts for 13% of all deaths; stroke is the third leading cause (WHO, 2013). These figures have been rising since 2000, when 2.7 million cases were reported, and by 2021 they had risen to 9.1 million (WHO, 2013).

One alternative that has currently had an impact on the prevention of CVD is the discipline of nutritional genomics, which studies the interaction between food and the components of the human genome at the molecular, systemic, and cellular levels. Advances in scientific training are crucial to understanding the complex interaction between our genes and diet (Castagnola and Castagnola, 2021). This discipline aims to use food as a fundamental tool for treating or preventing disease (Defagó and Eynard, 2022) and includes three branches: epigenetics, nutrigenetics, and nutrigenomics. The latter studies the relationship between nutrients and the genome and the variations that occur. Epigenetics refers to the hereditary patterns that activate or deactivate genes without changing the DNA sequence (Defagó and Eynard, 2022). Nutrigenetics is the branch of genetics that allows diets to be personalized by understanding how genes respond to an individual's diet (Defagó and Eynard, 2022).

Traditional dietary recommendations have played a special role in the prevention of CVD, but they also have limitations, and diet has been associated with the main risk factors in the etiology of CVD, mainly in the intake of total fat and different fatty acids (Corella and Ordovas, 2009). Nutrigenomics is a suitable approach for preventing and treating CVD, and the Mediterranean diet helps to

reduce IL-6 concentrations, thereby reducing the risk imposed by genetics (Corella and Ordovas, 2009).

Scientific question: What is the influence of the Mediterranean diet from a nutrigenetic and nutrigenomic perspective on the glycemic and lipid profile of teaching and administrative staff at the Bolivarian University of Ecuador as a strategy for the prevention of cardiovascular disease?

The objective of this study is to determine the cardiovascular risk of teaching and administrative staff at the Bolivarian University of Ecuador through biochemical analysis of their lipid and glucose profiles and the need to improve their diet by adhering to the Mediterranean diet.

Cardiovascular Diseases

Cardiovascular diseases are considered a major health problem in a nation's health system, and poor diet is considered one of the most significant factors in their incidence and prevalence (Egnell et al., 2019).

In response to this problem, health authorities have proposed public health policies, such as nutritional labeling, with the aim of improving the population's diet (Egnell et al., 2019); as well as increasing the consumption of fruits and vegetables that reduce the risk of coronary heart disease because they have a protective effect that improves blood pressure, which in turn influences other risks such as stroke and coronary heart disease (Egnell et al., 2019).

It is well known that excess weight is another risk factor in the development of CVD and is derived from poor diet and a sedentary lifestyle, although this has also been a source of controversy. The Framingham study showed that blood pressure increases by 6.5 mmHg with a 10% increase in total body weight; at the same time, other parameters such as plasma cholesterol and blood glucose are also affected by 12 mg/dL and 2 mg/dL, respectively (Gutiérrez et al., 2020).

On the other hand, the environment influences cardiovascular health to such an extent that there is also talk of environmental cardiology, which studies how environmental exposures are harmful when exposed to heavy metal pollution such as lead and cadmium in food, air, and water (Bañeras et al., 2022). Air pollution enters our body through the alveoli, activating mechanisms of inflammation, oxidative stress, thrombogenicity, and endothelial dysfunction. Contaminants from food and water can enter through the digestive tract (Bañeras et al., 2022), increasing the risk of ischemic events, heart failure, arrhythmias, and uncontrolled cardiac activity due to an increase in C-reactive protein and IL-6, which are inflammatory markers associated with an increased risk of CVD (Bañeras et al., 2022).

The Mediterranean diet and its influence on nutrigenetics and nutrigenomics

The Mediterranean diet was recognized by UNESCO (United Nations Educational, Scientific and Cultural Organization) as intangible cultural heritage of humanity because it encompasses knowledge, skills, traditions, and practices ranging from passage, harvesting, fishing, processing, and preparation to reaching the table with high nutritional content over time (Trichopoulou, 2021). . This diet has been used and recognized in Mediterranean coastal countries since the 1960s and is characterized by adequate consumption of vegetables, legumes, fruits, and cereals, the latter without any processing, low consumption of meat, moderate consumption of dairy products, and moderately high consumption of fish, as well as high content of unsaturated lipids such as olive oil, and low consumption of ethanol in the form of wine (Trichopoulou, 2021).

Adherence to the Mediterranean diet is associated with greater protection against cardiovascular diseases such as coronary infarction, coronary heart disease, cancer, diabetes, hypertension, neurodegenerative diseases, and reduced morbidity and mortality from the aforementioned pathologies.

An interaction between the gene and the Mediterranean diet has been found, so it is necessary to determine whether the effects of the Mediterranean diet are the same for the population in general, being greater or lesser, depending on the genetic variants of different diseases such as neurodegenerative, obesity, cardiovascular, certain types of cancer, cardiovascular, etc. (Trichopoulou, 2021).

Nutrigenetics and nutrigenomics are widely considered branches, since antioxidants from the Mediterranean diet contain polyphenols that are anti-inflammatory in nature and regulate metabolic and epigenetic activity, improving cardiovascular health (Kenanoglu et al., 2022). Flavonoids in cocoa have an antihypertensive effect by negatively regulating functional genes such as DNMTs and MTHFR, which are involved in the epigenetic process of peripheral blood mononuclear cells (Kenanoglu et al., 2022).

Hydroxycinnamic acids in citrus fruits such as kiwis, blueberries, cherries, plums, and others regulate autophagy and have an effect against DNA damage, stopping the cell cycle and the induction of apoptosis by inhibiting the epigenetic enzymes HDAC and DNMT, which are involved in the development of some types of cancer (Kenanoglu et al., 2022).

Anthocyanins in apples, pears, berries, red cabbage, blackcurrants, peaches, black soybeans, and grapes decrease inflammatory cytokines such as CRP and

TNF-**α**, which cause alterations in H3K4me3 and DNMT levels (Kenanoglu et al., 2022).

On the other hand, lignans in extra virgin olive oil (EVOO), coffee, tea, and whole grains have chemopreventive effects due to their antioxidant and anti-inflammatory properties. These compounds halt the cell cycle and apoptotic activity that promote DNA demethylation and positive regulation of H3K9me3 (Kenanoglu et al., 2022).

Alterations in lipid metabolism are related to genetic factors such as polymorphisms in the APOE, CETP, LPL, and PPAR-alpha genes (López Gamboa, 2024), which are related to the way the body metabolizes lipids, leading to a greater predisposition to atherosclerosis and other cardiovascular events. which is why they are being studied as they influence the body's response to fat intake (López Gamboa, 2024).

Genetic mutations are the result of habits and environmental changes to which we are exposed due to circadian disorder, a sedentary lifestyle, and poor diet. Daily stress, combined with chronobiological disorder, alters the individual's genetic makeup, leading to the onset of certain diseases (Spanish Heart Foundation, 2024). In the near future, it will be necessary to understand the individual human genome in order to apply nutrigenomics for the effective prevention of health problems in the population through personalized nutritional interventions (Spanish Heart Foundation, 2024) and to incorporate the Mediterranean diet, which is balanced and rich in omega-3, PUFA, EPA, and DHA (Guerrero et al., 2019).

Inadequate nutrient intake has an impact on nutrition and work performance, as it creates an obstacle to labor productivity in low- and middle-income countries (LMICs), compared to high-income countries where the workforce suffers greater health deterioration with higher job turnover and early retirement. In both cases, there is an increase in public and private healthcare costs (Drewnowski, 2020). It has been proven that a malnourished workforce does not allow for good economic growth because it reduces productivity for the company due to absenteeism (Drewnowski, 2020).

Obesity is associated with a lower quality of life and increases mortality because it induces the development of metabolic disorders such as hypertension, dyslipidemia, diabetes, stroke, coronary heart disease, sleep apnea, acute respiratory distress syndrome, and various types of cancer (Melián-Fleitas et al., 2021).

Reports from the World Health Organization (WHO) show that the prevalence of overweight and obesity is a global concern because it reduces quality of life and increases the risk of premature death due to overeating, insufficient physical activity, and high consumption of ultra-processed foods (Melián-Fleitas et al., 2021).

Among food and nutrition practices is a new concept of nutraergonomics, defined as "the interface between workers, their work environment, and their performance in relation to their nutritional status" (Melián-Fleitas et al., 2021). Nutrition is considered an integral part of a productive and safe workplace, where mental and physical health are also taken into account for the long-term well-being of workers (Melián-Fleitas et al., 2021).

Weight gain in administrative employees is related to spending 82% of their working hours sitting at their desks, which leads to an increase in total body fat and a loss of muscle mass, increasing BMI, due to compulsive behaviors with high-calorie foods in response to daily stress (Fierro Vaca et al., 2023). Worker well-being reduces labor productivity as BMI increases due to body fat, and health care costs also increase (Fierro Vaca et al., 2023).

Behavioral changes in eating habits and physical activity with favorable variables in BMI, anthropometric and biochemical measurements (Rachmah et al., 2022) can reverse overweight and obesity, as well as metabolic syndrome, type 2 diabetes mellitus, and dyslipidemia (Rachmah et al., 2022).

This study reviews the cardiovascular risk presented by the teaching and administrative staff of the Bolivarian University of Ecuador, through their lipid and glucose profiles and the need to improve their diet by adhering to the Mediterranean diet.

Based on a total population of 391 employees (including administrative and teaching staff) at the Bolivarian University of Ecuador, the sample size for the finite population was calculated using proportional sampling. The following parameters were considered for the calculation: 95% confidence level ($Z=1.96$), 9% margin of error ($e=0.09$), probability of occurrence of the event $P=0.5$, and its complement $Q=1-P=0.5$.

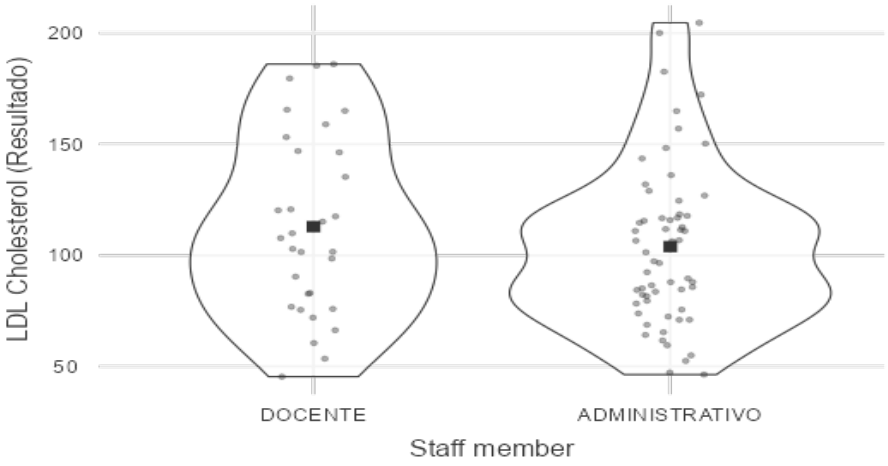
As a result, a sample size of 91 employees was obtained, distributed proportionally among 60 administrative staff and 31 teachers. Simple random sampling was used to select the participants.

The data comes from occupational health assessments carried out with informed consent, in accordance with Article 26, paragraph a) of the Personal Data

Protection Law, guaranteeing the legality and responsible use of the research, in compliance with the ethical principles governing research with human beings. Based on laboratory data obtained from the teaching and administrative staff of the Bolivarian University of Ecuador, and using descriptive statistical techniques and methods, the following results were obtained.

It is observed that the arithmetic mean of LDL cholesterol in teaching staff (113 mg/dL) is slightly higher than that of administrative staff (104 mg/dL), probably due to differences in lifestyle, such as higher intake of saturated fats or higher levels of stress in teaching staff. However, administrative staff show less dispersion in their values, as indicated by a standard deviation of 36.1 compared to 40.3 in teachers, suggesting greater consistency in their LDL cholesterol levels. The violin diagrams (Figure 1) show that the highest concentration of data for both teachers and administrative staff is below the mean, indicating a general trend toward lower values within each group.

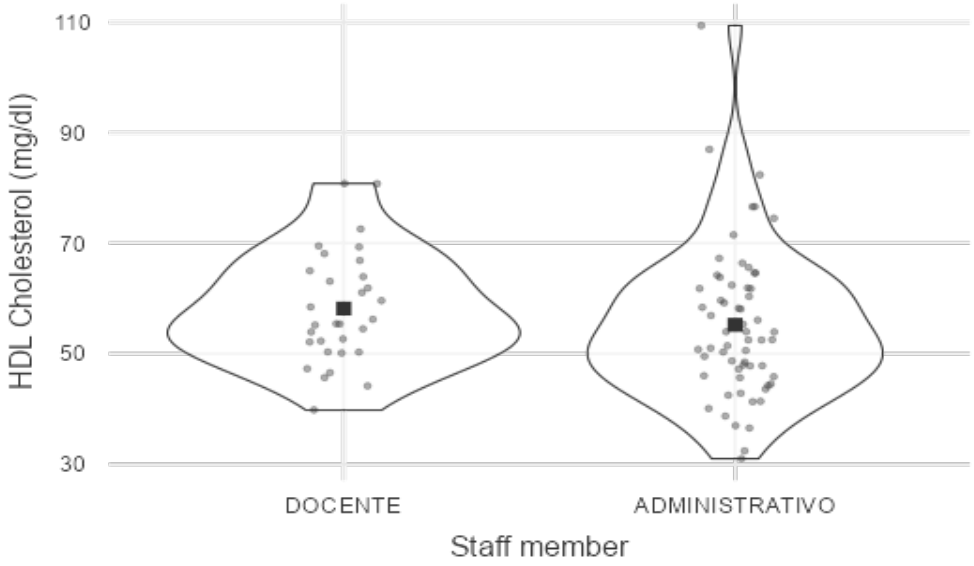
Figure 1 Violin diagram of LDL cholesterol by type of employee. Guayaquil, 2025



Source: authors

It can be seen that the arithmetic mean of HDL cholesterol in teaching staff (58.2 mg/dL) is slightly higher than that of administrative staff (55.2 mg/dL), probably due to differences in lifestyle habits, such as greater physical activity or a healthier diet among teaching staff. Similarly, teachers show less dispersion in their values, as indicated by a standard deviation of 10.1 compared to 13.7 in administrative staff, suggesting greater consistency in their HDL cholesterol levels. The violin diagrams (Figure 2) reveal very similar behavior in the HDL cholesterol values of both groups, and in both cases, the highest concentration of values is around the mean.

Figure 2 Violin diagram of HDL cholesterol (mg/dL) according to employee type. Guayaquil, 2025



Source: authors

Figure 3. Violin diagram of total cholesterol (mg/dL) according to type of employee. Guayaquil, 2025

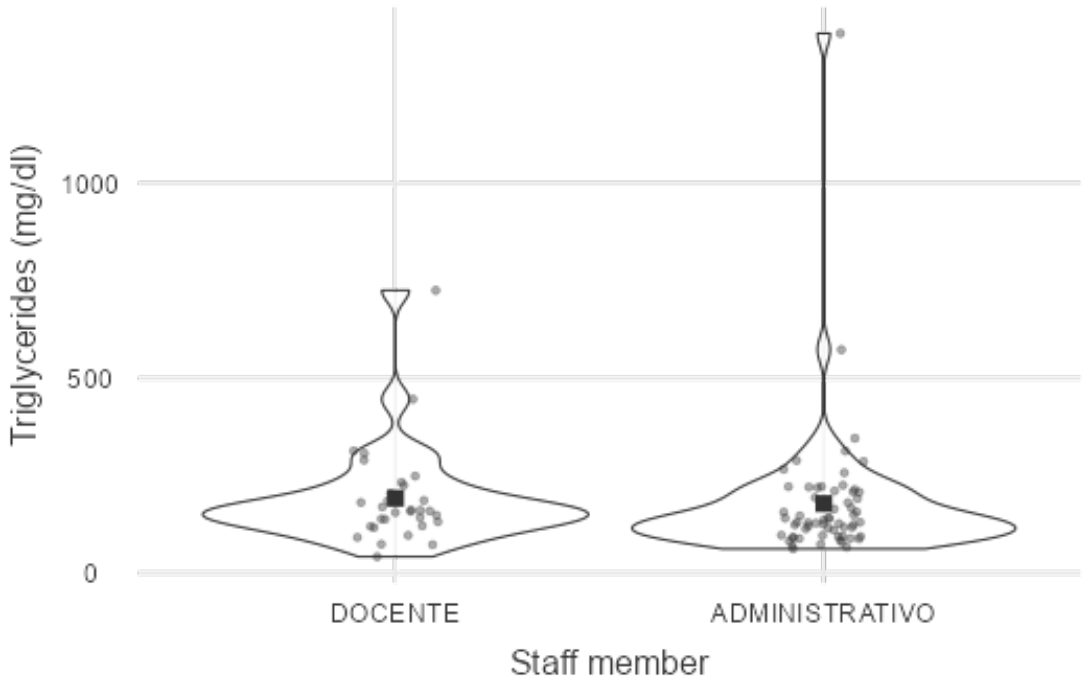


Source: authors

Figure 3 shows that the arithmetic mean of total cholesterol in teaching staff (205 mg/dL) is higher than that of administrative staff (188 mg/dL), probably due to factors such as a heavier workload, higher stress levels, or differences in diet that could contribute to increased cholesterol levels in teachers. However, administrative staff show less dispersion in their values, as indicated by a standard deviation of 39.2 compared to 46.2 in teachers, suggesting greater consistency in their total cholesterol levels. The violin diagrams (Figure 3) show that the highest concentration of data for teachers is around and below the mean, while for administrative staff it is mainly concentrated around the mean.

It can be seen that the arithmetic mean of triglycerides in teaching staff (192 mg/dL) is higher than that of administrative staff (179 mg/dL), probably due to differences in stress levels, diet, or physical activity between the two groups, as these factors significantly influence lipid metabolism. Similarly, teachers show less dispersion in their values, as indicated by a standard deviation of 129 compared to 179 in administrative staff, suggesting greater consistency in their triglyceride levels. The violin diagrams (Figure 4) reveal very similar glucose values, and in both cases, the highest concentration of glucose values is around the mean.

Figure 4 Violin diagram of triglycerides (mg/dl) according to employee type. Guayaquil, 2025



Source: authors

It can be seen that the arithmetic mean of glucose (mg/dl) is practically the same among teachers (98.7) and administrators (98.8). However, teachers show less dispersion in their values, as indicated by a standard deviation of 22.4 compared to 30.5 in administrators, suggesting greater consistency in their glucose levels. The violin diagrams (Figure 5) reveal very similar glucose values, and in both cases, the highest concentration of glucose values is around the mean.

Figure 5. Violin diagram of glucose (mg/dl) according to type of employee. Guayaquil, 2025



Source: authors

Several studies have shown that factors such as work stress, poor diet, and a sedentary lifestyle are directly associated with alterations in biochemical profiles, including glucose, cholesterol, and triglycerides.

Teaching staff are exposed to high levels of stress due to academic workload, assessments, and class preparation, which negatively affects their metabolic health (Carvajar and Villamar, 2022) (Ochoa-Vigo et al., 2022). This could explain the high levels of triglycerides and total cholesterol found in this group.

On the other hand, a study by the University of Guayaquil (2019) showed that the presence of dyslipidemia and other cardiovascular risk factors is associated with both a sedentary lifestyle and eating habits in the administrative and teaching staff of an educational institution, which coincides with the patterns observed in the present analysis (Miguel, 2018).

Likewise, research such as that conducted by the Technical University of the North (2015) highlights the importance of monitoring biochemical factors in the workplace as a preventive strategy for cardiovascular disease, recommending institutional interventions that promote healthy lifestyles (Maldonado and Nicolalde, 2015).

Finally, comparative studies such as that of the National University of Loja (2015) emphasize that glucose and lipid levels are significantly higher in sedentary individuals than in those who engage in regular physical activity, which reinforces the need for differentiated occupational health programs for teachers and administrators (Garcés & Cruz, 2013).

Conclusions

Administrative and teaching staff, faced with chronic stress, sedentary lifestyles, and poor eating habits, are highly exposed to metabolic risk factors due to alterations in their lipid and glycemic profiles. Therefore, there is a clear need to implement occupational health programs aimed at promoting healthy lifestyles.

From a nutrigenomic perspective, the Mediterranean pattern should be incorporated as a nutritional strategy to prevent cardiovascular disease in employees of the Bolivarian University of Ecuador, to improve the lipid and glycemic profile, since the Mediterranean diet acts at the genetic level by modulating gene expression involved in inflammation, lipid metabolism, and oxidative stress response due to its high content of bioactive compounds from fiber, polyphenols, and monounsaturated fatty acids that contribute to reducing cardiovascular risk in a personalized and effective manner.

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Improving Educational Quality and University Policy by Forming Competencies for Competitiveness

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Introduction

In the dynamic landscape of the 21st century, competitiveness has solidified as a global imperative, transcending economic spheres to profoundly impact social and individual development. This inherent demand for human interaction manifests from competition in sports to the rigorous requirements of the labor market. It is in this scenario that higher education assumes a leading and irreplaceable role, standing as the epicenter for the generation, dissemination, and application of knowledge—fundamental pillars in the formation of competencies that graduates will leverage for their professional development and, by extension, for strengthening national productivity and economic growth.

This study focuses on analyzing the complex interconnection among competency development, educational quality, and university policy at the higher education level, with the purpose of elucidating how these dimensions converge to enhance the competitiveness of future professionals. To achieve this, we will examine the evolution of competitiveness theories, starting from the foundations of competitive advantage proposed by Porter (2015) and progressing toward Lundvall's (1992, 2019) perspectives on knowledge-based competitiveness, which position the university as an essential driver of innovation and intellectual development. Likewise, contributions from Valero (2023), who emphasizes the criticality of measurement in any competitiveness strategy, will be integrated. The synthesis of these theories will allow us to support that quality education is a multifaceted construct demanding a holistic approach to forge highly competitive professionals adapted to the demands of the 21st century.

Emphatically, this research will focus on the competitiveness of graduates from programs offered by the Faculty of Accounting and Administrative Sciences at the Michoacán University of San Nicolás de Hidalgo. It starts from the fundamental premise that true individual competitiveness manifests in the ability to apply knowledge and skills in diverse scenarios, both conventional and emerging (Ahumada Tello, 2017), recognizing that organizational success is

intrinsically linked to the competitive development of its collaborators. In this regard, we will analyze how pedagogical and didactic strategies influence the acquisition and refinement of key professional competencies, such as leadership, teamwork, results orientation, and personnel management.

The central objective of this article is to conduct an exhaustive analysis of competency development for competitiveness, considering the intersection of educational quality and university policy, in order to determine the specific influence of pedagogical and didactic strategies in this formative process.

Competency Development

Competency development is a central paradigm in 21st-century higher education, moving beyond the traditional content transmission model to focus on the comprehensive preparation of individuals for effective performance in complex contexts. Tobón (2005) defines them as the mobilization of diverse resources (knowledge, skills, attitudes, values) to solve real problems, beyond theoretical knowing. This paradigm is vital for employability and talent management (Ulloa, 2015), with distinctive competencies being a crucial factor in the demanding labor market (Vicente, 2024). Therefore, higher education must develop the ability to apply knowledge proficiently and adapt to professional dynamics.

Types of Competencies

Competencies are classified into Generic (Transversal) and Specific (Technical). Generic competencies, such as critical thinking, teamwork, and effective communication, are essential across various professions (Crespí, 2021). Specific competencies, in contrast, are specialized knowledge and skills for particular professional tasks, such as preparing financial statements or project management in Accounting and Administrative Sciences.

Professional Competencies

Professional competencies are the integrated set of knowledge, skills, attitudes, and values that capacitate an individual for effective performance in a specific professional role (Gutierrez Larotta, 2018). Acquired through academic training and practical experience, they are fundamental for career success. The most demanded competencies include: Leadership, Teamwork, Results Orientation, and Personnel Management. Their continuous development is vital for the successful integration of graduates into the labor market, directly impacting their individual competitiveness.

Competitiveness

Competitiveness is a multidimensional concept that has evolved from a simple advantage in costs or quality to the ability to generate and sustain differentiating advantages (Siudek & Zawojska, 2014; Raenz, 2021). This study addresses competitiveness from three perspectives: Competitive Advantage (Porter, 2015), which seeks superior performance through the creation of unique value; Knowledge-Based Competitiveness (Lundvall, 1992), Science, Technology, and Innovation Policy: Old Patterns and New Challenges (Lundvall, 2019), where the university is an engine of innovation and human capital development; and Competitiveness Measurement (Valero, 2023), indispensable for evaluating and adjusting strategies. Fundamentally, individual competitiveness resides in the practical application of knowledge in diverse situations, highlighting its dynamic and applied nature (Ahumada Tello, 2017).

Competitiveness in Higher Education

Competitiveness in higher education goes beyond merely attracting students or resources; its crucial function is to train graduates capable of successfully competing in the labor market and contributing to socioeconomic development. Society demands that higher education be more efficient in assimilating skills for professional development (Gómez, 2019), a true "social mandate."

This approach implies that institutions must go beyond instruction, fostering meaningful learning and the acquisition of competencies that transcend the academic. The quality of training is, therefore, a determining factor for future professionals to face the challenges of a dynamic work environment.

Competitiveness through Educational Quality

Educational quality is the pillar of the competitiveness of graduates and higher education institutions. Achieving it requires a comprehensive approach that encompasses curriculum review, innovative pedagogical methodologies, faculty qualification, resource availability, and relevance to the labor market. The implementation of effective pedagogical and didactic strategies is crucial for fostering the acquisition of competencies, enabling a significant transfer of knowledge (Torres, 2017). University policy is fundamental in establishing the framework for high-quality educational programs. In synthesis, the competitiveness of graduates is a direct reflection of the educational quality received, molded by university policies and innovative pedagogical strategies. This framework guides the analysis in the Faculty of Accounting and Administrative Sciences at the Universidad Michoacana de San Nicolás de Hidalgo.

Pedagogical and Didactic Strategies for Competency Development

The transformation of higher education in the 21st century demands a paradigmatic shift from a content transmission-centered model to one focused on competency development. This imperative responds to the growing demands of society and the productive sector, which require graduates with applied, innovative, and adaptable capabilities. In this context, the selection and implementation of relevant pedagogical and didactic strategies become crucial.

Foundations and Selection of Pedagogical Strategies

After an exhaustive review of more than 25 pedagogical strategies, collaborative work was identified as the most robust and transversal approach for the comprehensive formation of competencies. This choice is based on its capacity to promote interrelation in the teaching-learning process and its support by a vast body of scientific research, reflected in reference academic literature.

Contemporary higher education institutions (HEIs) transcend their traditional function of mere teaching. They project themselves as agents of change, committed to research, cultural dissemination, and the resolution of current problems (Sánchez-Otero, 2019). This evolution is driven by social demand for more inclusive HEIs that foster participation and lead social transformation through science, technology, and innovation, in order to optimize production methods and generate a positive impact in social, political, and economic spheres.

The success of these strategies depends on the dynamic interaction among the teacher, student, content, and didactic strategy. The teacher's role is redefined, shifting from a mere transmitter of information to a guide and designer of learning experiences (Benítez, 2019). Their work consists of conceiving activities that not only facilitate knowledge acquisition but also promote student self-assessment and autonomy in their own learning process. In this sense, the integration of Information and Communication Technologies (ICT) emerges as a fundamental pillar. ICTs not only enrich learning environments but also position the student as an active protagonist of their training, opening new avenues for synchronous and asynchronous communication through digital platforms and interactive tools (Lizcano, 2019; Sánchez et al., 2019).

The proper selection and application of pedagogical strategies directly influence the quality and academic performance of students (Salazar, 2018). For this, strategies must meet criteria of clarity, variety, relevance, and validity, ensuring the consolidation of imparted knowledge (Ausín, 2016). Modern education must capitalize on global technological transformations, leveraging distance

modalities and global connectivity to break down geographical barriers and democratize access to knowledge (Sánchez-Otero, 2019).

Collaborative Work as a Central Strategy

Collaborative work stands as a high-impact pedagogical methodology that transcends the mere grouping of individuals. In an educational context, it configures an interactive model that cultivates interest in joint improvement, encouraging students to combine efforts, competencies, and talents to achieve shared learning goals. This strategy not only strengthens mutual respect among team members but also fosters positive interdependence, a distinctive feature that differentiates it from traditional group work. Task resolution in collaborative work demands an active commitment to the exchange of communicative and technical skills to achieve efficiency. Chaljub (2015) emphasizes that collaborative work must be conceptualized as a rigorous methodology, which requires a clear theoretical framework to validate its application in the teaching process. This model is based on the premise that social communication skills are intrinsic to a pedagogical process that enhances the collective construction of learning through continuous dialogue. According to Chaljub (2015), collective learning is the inherent result of collaborative work, characterized by the fostering of critical and divergent thinking, without detaching from logical reasoning and creativity—essential principles for socialization and positive interdependence among learners.

It is crucial to differentiate between the concepts of cooperative and collaborative learning. Zañartu (2013) clarifies that cooperative learning is a process initially structured by the teacher, who gradually cedes responsibility to the student, transforming into a collaborative model. This distinction is framed within the theoretical strands of Piaget (cooperative) and sociocultural theory (collaborative) (Escolano, 2017). Both perspectives converge in supporting constructivism as a fundamental pedagogical current for contemporary teaching-learning. The successful implementation of collaborative work in the classroom requires the application of appropriate techniques that facilitate its practice (Revelo, 2018). A fundamental aspect for its effectiveness lies in active interaction and communication among peers, which has been consistently pointed out by various researchers as a key strategy for collaborative learning (Magide, 2021). Furthermore, ICTs offer significant pedagogical advantages to enhance collaborative learning, by stimulating interpersonal communication through digital platforms that facilitate synchronous and asynchronous interaction (Lizcano-Dallos, 2019). The connection between academic abstraction and "practical" application is of utmost importance and must be concretized (Ostrosky, 2018). Students must actively build connections in their

own brains and minds for meaningful learning (Glejzer, 2017), encompassing: a) Neurological connections, b) Cognitive connections, and c) Social connections.

The results of this research confirm that the strategic implementation of pedagogies and didactics in the teaching-learning process significantly improves educational quality and university policy, which in turn optimizes competency development for graduate competitiveness. These strategies provide teachers with more effective tools to interact with students, promoting a dynamic and participatory learning environment.

It is highlighted that the incorporation of Information and Communication Technologies (ICT) into university pedagogical models is crucial to meet current social and professional demands. In particular, collaborative work emerges as a pedagogical strategy of great relevance because it fosters intensive communicative interaction and commitment in skill exchange, enhancing both interpersonal relationships and technical skills. This synergy, complemented by the use of ICT, facilitates the practical application of knowledge in real contexts and promotes the development of essential neurological, cognitive, and social connections for meaningful learning and sustained competitiveness in graduates.

Conclusions

This study underscores the indispensable connection between quality higher education and graduate competitiveness, which are fundamental pillars for socioeconomic development in today's dynamic landscape. We reaffirm that the development of professional competencies is essential, transcending the mere transmission of knowledge to ensure that future professionals not only adapt but also lead change. For this transformation, it's imperative and crucial to evolve from traditional educational methodologies to active, student-centered approaches. This requires a holistic commitment from the academic community to implement innovative pedagogical strategies, ensuring that the educational system equips graduates to effectively apply their learning.

Our research highlights collaborative work as a central pedagogical strategy, fostering interaction, skill exchange, and knowledge co-construction. Complementarily, the effective integration of Information and Communication Technologies (ICT) enriches learning environments, positioning the student as an active agent and facilitating the practical application of knowledge. This synergy is vital for developing professionals capable of generating value in an interconnected world. The combination of educational quality, relevant university policies, and innovative pedagogical strategies equips professionals to face the challenges of the 21st century, driving innovation and economic

growth. This implies a call for universities to invest in faculty training and technology, and to continuously revise curricula, ensuring constant alignment with market demands and global trends. The success of higher education in forming competitive professionals will depend on this proactive and unified vision.

The competitiveness of university graduates is a fundamental pillar for socioeconomic development. In a dynamic and globalized labor environment, quality higher education is the primary catalyst for strengthening the knowledge, skills, and abilities that allow professionals to perform effectively and adapt to constant changes. It is imperative to transcend traditional educational methodologies toward more active and student-centered approaches, which requires an integral commitment from teachers, students, and institutions. To achieve effective competency development, the educational system needs profound transformations that promote the application of innovative strategies such as collaborative work and the effective integration of ICT. This ensures that graduates not only acquire knowledge but also develop the ability to apply it to generate value in an interconnected and constantly evolving world, anticipating and responding to the demands of competitiveness that society requires.

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Preparing higher education teachers to support students with disabilities

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Introduction

Inclusive education has become a central pillar in the transformation of education systems worldwide. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021), this approach seeks to ensure that all students, regardless of their individual characteristics, have equal access to quality education, promoting more just and inclusive societies. In this vein, the Incheon Declaration (UNESCO, 2016) emphasized the importance of moving toward an educational model that addresses diversity and encourages the participation of all students, highlighting teacher professional development as a key factor in achieving this.

Several studies have shown that teacher training in inclusive strategies has a direct impact on teachers' preparedness to respond to diversity in the classroom (Sánchez et al., 2021). De la Llana and Delgado (2023) assert that ongoing training in inclusive methodologies enables teachers to design flexible learning experiences and apply adaptive approaches that address the diverse needs of students. Along the same lines, Lizarro (2020) and Sangrà et al. (2023) emphasize that the development of teaching competencies must include skills in differentiated curriculum planning, effective communication, adaptive assessment, and inclusive classroom management, which are fundamental aspects for creating accessible and equitable learning environments.

An essential element of inclusive education is the creation of learning environments that promote the equitable participation of all students. According to Bell (2023), inclusive teaching is not limited to integrating students with disabilities into the regular classroom, but requires the design of learning spaces that respond to the heterogeneity of the student body. To achieve this, teachers must adjust content, diversify teaching materials, and apply active methodologies that promote student autonomy and meaningful learning. In this context, UNESCO (2021) recommends the adoption of Universal Design for

Learning (UDL), an approach that allows for flexibility in the curriculum and the adaptation of pedagogical strategies to accommodate different learning styles and paces.

With the aim of improving teacher training in inclusive education and taking into account the proposals of Duk et al. (2019) and Márquez et al. (2021), the institution implemented various strategies in line with international recommendations on professional development and improving educational quality in diverse contexts. One of the key actions was training in educational inclusion, focused on providing teachers with pedagogical tools to address diversity in the classroom. Likewise, monthly workshops and seminars were held on educational regulations and inclusive methodologies, strengthening the application of strategies adapted to different contexts. Training in formative and differentiated assessment was also promoted, providing tools to more accurately identify students' individual needs (Turpo & Pérez, 2021).

The use of educational technology was another fundamental pillar of the teacher preparation strategy. Digital platforms and accessible interactive resources were incorporated, facilitating access to up-to-date information on inclusive education. Technological tools were also implemented, such as accessibility software for students with disabilities and adaptive learning platforms. In addition, the diversification of assessment tools was promoted, including rubrics, digital portfolios, and adaptive questionnaires, which allowed for a more equitable measurement of learning, as proposed by Álvarez-Herrero (2020). Complementarily, the application of inclusive and adaptive methodologies was encouraged, ensuring equity and the active participation of students in their educational process.

To guarantee the effective application of the knowledge acquired in teaching practice, assessment and monitoring plans were established. The use of inclusive rubrics and formative assessment systems was promoted, ensuring equitable monitoring of student progress. Flexible assessment adapted to diversity was also promoted, adjusting assessment criteria to different learning paces. As a complement, strategies such as project-based learning were strengthened, taking into account the proposals of Orellana (2020), as well as guided self-assessment, allowing students to reflect on their own learning process. In addition, emphasis was placed on ethics in assessment, ensuring objectivity and transparency in grading criteria.

The strategies implemented improved classroom organization and accessibility, adjusting the layout of the space for flexible grouping and ensuring equal opportunities for participation. The use of adaptive resources and time

management in inclusive activities was optimized, facilitating more efficient planning. In addition, collaborative work among teachers was encouraged through inter-institutional networks and spaces for the construction of inclusive strategies, taking into account the experience of Marrero et al. (2019). Communication with students was strengthened, ensuring that they could share ideas and strengthen their autonomy in the classroom.

After implementing these strategies, the Questionnaire for the Evaluation of Teacher Competencies in Attention to Diversity was reapplied to participating teachers, with the aim of measuring the impact of teacher preparation strategies and analyzing changes in their competencies. This new evaluation sought to identify improvements in key areas such as curriculum planning, the use of inclusive methodologies, classroom management, and adaptive assessment, as well as to detect those dimensions that still require strengthening. The results obtained not only demonstrated progress in teacher preparation to address diversity but also guided future training actions to ensure more equitable and quality education.

The following questions are raised:

- What level of training do university teachers have to cater to students with disabilities?
- What pedagogical strategies do teachers implement to facilitate the learning of students with disabilities?
- What competencies should a higher education teacher have to cater to students with disabilities?
- How do teachers perceive the effectiveness of their training in catering to students with disabilities?
- Topics in the chapter "The preparation of higher education teachers to serve students with disabilities"

This chapter refers to a study conducted during the 2023-2024 period at a higher education institution where a program for assisting students with disabilities was implemented. The study evaluated the skills acquired after its implementation, showing a significant change in all the skills evaluated, which demonstrates the importance of preparing higher education teachers to meet the challenge of assisting people with disabilities in order to provide adequate support. It also shows that training involves not only acquiring technical knowledge, but also developing pedagogical, attitudinal, and ethical skills that promote inclusive and equitable environments.

Among the topics to be addressed in this chapter are

1- The importance of preparing higher education teachers for inclusive care
2- Challenges in teacher training
3- The connection between neuroscience and education
4- Neuroeducational strategies for inclusion
5- Universal Design for Learning (UDL)
6- Emotional regulation techniques
7- Multisensory teaching
8- Use of assisted technology.
9- Fostering collaboration and peer learning
10- Impact of neuroscience-based teacher training

Importance of preparing higher education teachers for inclusive education

Educational inclusion in the university setting requires teachers to be trained to identify and respond to the diverse needs of students with disabilities. This involves understanding the barriers these students face and adapting teaching strategies to facilitate their learning and active participation. A lack of teacher preparation can limit opportunities for these students and perpetuate exclusion (Duche-Perez et al., 2024).

Consequently, we take as a reference the analysis from this same perspective.

Teacher training for educational inclusion has been a priority issue in reports and political debates in recent years (Vaillant 2009). There is consensus that the educational inclusion of students cannot be achieved without the decisive intervention of teachers. For this to be possible, it is necessary to place it at the center of education and demonstrate that progress cannot be made in this area without simultaneously improving the understanding of what teachers believe, can do, and do.

This analysis of teacher training emphasizes another relevant aspect that undoubtedly leads to an understanding of the importance of teacher training for the care of students with disabilities. In this regard, it states:

Latin American teachers are trained in institutions of all kinds (Vaillant 2005): in higher education institutes, provincial or municipal institutes, higher technical education institutions, universities, private institutions, and there are also those who work as teachers without having a degree that qualifies them for such a task. The third has to do with training content and the relationship between pedagogy and didactics. However, as Denise Vaillant (2007) points out, these reform processes have not solved such important problems in teacher training as the

divorce between theory and practice; the fragmentation of training content; the weak relationship between pedagogy and specific teaching methods; and the complex relationship between teacher training centers and the places where teaching practice takes place.

Another important aspect to consider is what skills a higher education teacher needs to work with students with disabilities. Among the most notable are critical and creative thinking, mastery of curriculum teaching, teamwork, and interdisciplinary work, among others. However, these can be questioned from the perspective of each researcher, since each educational context has its own demands, and each of these must be taken into account in order to adapt them to the context in which they are developed. Hence, we take the following analysis as a reference: companies demand skills and values such as teamwork, responsibility, and initiative from the education system, which they do not subsequently use; they demand that educational institutions become increasingly diverse, so that teachers must recognize and promote the existence of different learning styles, heterogeneous grouping of students, the integration of students with special needs into regular classes, the development of cross-curricular skills, as well as the creation of interdisciplinary relationships between different subjects. At the same time, there is a greater concern for homogenizing and comparing performance (Vaillant 2009).

Everything analyzed in this section makes us reflect on the indisputable need for teacher training to apply correct inclusion and attention to educational diversity in the teaching context.

Challenges in teacher training

Teachers play an essential role in creating inclusive educational environments, as they are responsible for designing transformative learning experiences. However, a lack of adequate training limits their ability to address diversity in the classroom, especially in students with disabilities. This training gap has a negative impact on educational equity and quality, hindering the implementation of effective inclusive practices.

Lack of specific knowledge: According to Crispel and Kasperski (2019), many teachers do not feel prepared to meet the needs of students with disabilities. The lack of training in adapting materials, using assistive technology, and neuroeducational strategies perpetuates homogeneous pedagogical approaches that ignore diversity, fostering the exclusion of these students.

Limited infrastructure and resources: Collins et al. (2019) highlight the lack of accessible facilities and technological tools as a major challenge. The absence

of resources such as ramps, screen reading software, or augmentative communication devices limits both student participation and teachers' ability to support them.

Workloads and lack of time: Crispel and Kasperski (2019) point out that high work demands make it difficult for teachers to train in inclusive methodologies, relegating the needs of students with disabilities to immediate priorities.

Attitudes and prejudices: Morris et al. (2021) emphasize that prejudices and ignorance about less visible disabilities perpetuate exclusion.

This leads to discriminatory practices and a lack of necessary accommodations for equitable student participation.

Overcoming these challenges will not only benefit students with disabilities, but will also enrich teaching practice by preparing teachers to address diversity in all its forms. By integrating principles from neuroscience and promoting inclusive policies, we can move toward a more equitable and accessible higher education for all.

The connection between neuroscience and education

Neuroscience, as an interdisciplinary discipline, provides key insights into learning, memory, and emotions, offering tools to improve the educational experience. Its integration into education allows for the design of evidence-based strategies that address the needs of students, especially those with disabilities. In the context of inclusive education, neuroscience promotes adapted pedagogical interventions, transforming educational environments into more equitable and inclusive spaces, favoring the comprehensive development of all students.

Key principles of neuroscience applied to education:

Neuroplasticity: Neuroplasticity, the brain's ability to adapt and reorganize itself in response to new learning, allows teachers to design strategies that promote cognitive development even in students with physical or cognitive limitations. Methods such as hands-on activities, multisensory stimuli, and positive reinforcement take advantage of this ability to promote meaningful learning. According to Simões et al. (2022), these interventions benefit both students with disabilities and the classroom as a whole by providing equitable learning opportunities.

Neurocognitive diversity: Differences in how students process information, influenced by genetic factors, experiences, and cultural contexts, highlight the

need for personalized teaching methods. Gkintoni et al. (2023) emphasize that adapting teaching strategies to students' unique profiles fosters more effective and respectful learning. For example, some students prefer visual approaches, while others respond better to auditory or kinesthetic methods, thus strengthening inclusive educational practices that value diversity.

Importance of the environment: The emotional and social environment directly affects educational outcomes. Kumar (2023) emphasizes that a safe and cognitively enriched classroom is crucial for students with disabilities, who face higher levels of stress. Strategies such as clear routines, emotional regulation, and open communication build positive environments that promote learning.

Practical application: Implementing these principles allows teachers to address students' academic and emotional needs.

Integrating neuroscience into education transforms educational environments into accessible and equitable spaces. These key principles provide tools for designing pedagogical interventions that promote academic success and emotional well-being for all students, with a significant impact on those with disabilities.

Neuroeducational strategies for inclusion

Neuroeducation, as an interdisciplinary approach, combines principles from neuroscience and education to design evidence-based pedagogical strategies that promote inclusive and effective learning. This approach is especially relevant for addressing diversity in the classroom, allowing students with disabilities to fully participate in the educational process and reach their full potential. By applying neuroscientific principles, teachers can overcome traditional barriers and ensure a meaningful and positive learning experience. Among the most notable strategies are models such as Universal Design for Learning (UDL), emotional regulation techniques, multisensory teaching, the use of assisted technology, and the promotion of peer collaboration.

Universal Design for Learning (UDL)

UDL is a pedagogical model that seeks to create accessible and equitable learning environments from the initial design stage, avoiding the need for subsequent adaptations. This approach promotes inclusion by considering the diverse ways in which students process and demonstrate learning. According to Capp (2017) and McKenzie and Dalton (2020), UDL is based on three fundamental principles:

Provide multiple forms of representation: This principle emphasizes the importance of presenting information through different modalities (visual, auditory, kinesthetic), ensuring that students with diverse sensory and cognitive abilities can access the content. For example, the use of diagrams, videos, narrations, and manipulative materials allows each student to select the format that best suits their needs and learning styles.

Facilitate multiple forms of expression: Allowing students to demonstrate their learning through various tools and methods encourages active participation and reduces barriers. Students can choose to create presentations, write essays, conduct hands-on experiments, or use technology to show what they have learned, which is particularly useful for those with motor or communication disabilities.

Encourage multiple forms of engagement: Designing activities that are relevant and motivating for students is essential to maintaining their interest and participation. This principle includes implementing meaningful tasks, incorporating individual interests, and promoting challenges that encourage self-improvement.

UDL not only benefits students with disabilities, but also enhances the learning experience for the entire class by offering flexibility and personalization in the educational process.

Emotional regulation techniques

Emotions play an essential role in learning, as they directly impact attention, memory, and motivation, which are key aspects of academic performance. Incorporating emotional regulation strategies in the classroom helps students manage stress and anxiety, significantly improving their performance. Among the most effective techniques is mindfulness, which promotes full attention, reduces anxiety, and strengthens self-regulation. In addition, teaching social-emotional skills allows students to recognize and manage their emotions, establish positive relationships, and make responsible decisions, which promotes a more harmonious environment. Complementarily, creating emotionally safe environments based on respect, mutual support, and trust encourages active participation and student well-being, contributing to a more positive and inclusive educational experience.

Multisensory teaching

Multisensory teaching is particularly effective for students with sensory or cognitive disabilities, as it involves multiple sensory pathways to facilitate understanding and retention of learning. According to Alenizi (2019), activities

that combine visual, auditory, tactile, and kinesthetic stimuli can significantly improve learning by reinforcing information through different channels. For example, the use of manipulative materials in mathematics, reading aloud accompanied by images, or conducting practical experiments in science allows students to assimilate content more effectively. This approach also encourages active participation and interest in the lesson.

Use of assistive technology

Assistive technology is an essential tool for removing educational barriers and promoting autonomy among students with disabilities. Atanga et al. (2019) highlight the positive impact of devices such as screen reading software, which allows students with visual impairments to access digital texts through audio; augmentative communication applications, which facilitate interaction for students with speech or language disabilities; and eye-tracking devices, which enable students with motor disabilities to operate computers and digital tools. These technologies not only expand access to educational content, but also promote active participation in academic and social activities, strengthening their inclusion and ability to function in diverse environments.

Promoting collaboration and peer learning

Collaborative learning is an effective strategy for promoting inclusion and developing social skills. According to Toulia et al. (2021), designing activities in which students work in teams allows those with disabilities to interact and learn alongside their peers in a mutually supportive environment. These interactions foster empathy, cooperation, and problem-solving among all students, contributing to a culture of inclusion. In addition, peer learning dynamics can serve as an additional support network for students with disabilities, who benefit from the perspectives and skills of their peers.

Impact of strategies

The implementation of these neuroeducational strategies not only improves learning for students with disabilities, but also transforms the classroom into a more inclusive and equitable space. Teachers who apply these practices strengthen their ability to address diversity, while the educational institutions that support them contribute to the promotion of accessible education for all. This comprehensive approach ensures that no student is excluded from the right to a quality education, aligning with the principles of equity and social justice.

Impact of neuroscience-based teacher training

The results of implementing neuroeducational strategies in teacher training have a significant and multidimensional impact on the education system, benefiting

students, teachers, and institutions. These strategies, based on scientific principles, not only contribute to improved academic outcomes but also to the construction of more inclusive, equitable, and efficient educational environments. The effects at each level are detailed below:

On students: The implementation of neuroeducational strategies allows for the specific needs of students to be addressed, increasing their participation, motivation, and academic achievement. These personalized practices reduce dropout rates and improve the perception of inclusion in the university environment, strengthening the sense of belonging and promoting a positive educational experience for all students (Procopio et al., 2022).

For teachers: Training in neuroeducation empowers teachers by providing them with practical tools to address diversity in the classroom, increasing their confidence and pedagogical skills. This improves their well-being at work and professional satisfaction by reducing the stress associated with lack of preparation, while also contributing to their ongoing development and commitment to inclusive teaching (McMahon et al., 2019).

In institutions: Universities that adopt neuroeducational strategies strengthen their reputation as inclusive spaces and comply with ethical and legal standards of equity. This approach encourages the retention of a diverse student population and promotes an academic environment that reflects the values of a just society, contributing to the formation of citizens who are aware of and prepared for diversity (Collins et al., 2019).

"Analysis of teacher preparedness for the care of students with disabilities in higher education"

The study variables in this research were as follows:

Independent variable: Higher education teacher preparedness

Dependent variable: Care for students with disabilities

Problem situation:

Nowadays, it is common to hear that inclusion and attention to educational diversity are priority issues.

Internationally, in various regions of the world, efforts are being made to achieve the highest standards, although this is complicated because it depends on government support for this noble task.

If we analyze the Latin American context, this is even more true, since in addition to the scarcity of resources and government policies, there is also a lack of resources to promote teacher preparation or training opportunities.

In Ecuador, this is also a latent reality because, although the government and the Higher Education Council have policies that demonstrate the need to implement and enforce regulations established to address inclusion in every higher education classroom, those that are implemented are still insufficient due to several factors, such as the lack of programs designed for teacher training in diversity awareness and inclusion.

The dimensions evaluated were: Academic Competencies, related to initial and continuing training, knowledge of regulations, and training management; Teaching Competencies, which include content adaptation, the use of inclusive methodologies, and the implementation of pedagogical strategies; Organizational Competencies, focused on time management, classroom organization, and student distribution; Communicative Competencies, which assess interaction with students, effective communication, and interdisciplinary work; Integrative Competencies, which include the use of inclusive technologies, collaborative work, and equitable attention; and Assessment Competencies, aimed at the application of adaptive assessment strategies and personalized feedback.

The questionnaire was recently administered to the 30 teachers who participated in the initial assessment, allowing for a direct comparison between the results obtained before and after implementing the preparation strategies. To measure competencies, a five-level Likert scale based on Matas (2018) was used, in which teachers indicated their level of agreement or frequency with each statement. The levels of the scale were: "Not at all" (1 point), when the teacher does not perform the mentioned action; "A little" (2 points), when they perform it occasionally, but with difficulty or infrequently; "Moderately" (3 points), when they perform it acceptably, although with room for improvement; "Quite a lot" (4 points), when they implement it regularly and effectively; and "A lot" (5 points), when they have completely mastered it and apply it consistently in their teaching practice.

To ensure accessibility and convenience in the application of the questionnaire, it was administered using a Google Forms form, sent to teachers via their institutional email. A two-week deadline was set for completing the survey anonymously and voluntarily, ensuring the free participation of respondents. Once all responses were collected, the data were processed and analyzed using SPSS (Statistical Package for the Social Sciences) software, following the

guidelines of George and Mallery (2019). Descriptive analyses were performed to compare the results obtained in both measurements, which made it possible to identify progress in each dimension evaluated, measure the effectiveness of the strategies implemented, and detect those areas that still require strengthening in teacher preparation for attention to diversity.

To analyze the impact of the strategies implemented, the percentage improvement in each item evaluated was calculated by comparing the means obtained in 2023 and 2024. To do this, the following formula was used: Improvement (%) = ((Average 2024 - Average 2023) / Average 2023) × 100, where the difference between the two measurements is divided by the initial average and multiplied by 100 to obtain the percentage increase. This calculation made it possible to identify the areas with the most progress and those that still need strengthening, providing a quantitative view of the impact of training strategies on teacher preparation for addressing diversity.

The study is part of a quantitative approach, following the approach proposed by Hernández-Sampieri and Mendoza (2018), as it is based on the collection and analysis of numerical data to evaluate changes in teaching competencies. Furthermore, according to the criteria of Creswell and Creswell (2018), it is a longitudinal study, as it examines the evolution of these competencies over the course of a year. It is also classified as a descriptive study, according to Aggarwal and Ranganathan (2019), since its objective is to characterize and analyze the changes that occurred after the implementation of the training strategies.

In terms of research design, this corresponds to a pretest-posttest without a control group, as described by Privitera (2022). This means that the same participants were evaluated at two different times: before the implementation of the training strategies (2023) and after one year of application (2024). This approach made it possible to measure the impact of the strategies and determine which areas showed significant improvements, as well as those that still require adjustments or reinforcement.

The sample consisted of the 30 teachers who participated in the initial evaluation conducted by Pacheco et al. (2023), thus maintaining consistency in the comparison of results. The sample distribution remained balanced in terms of gender, with 15 women and 15 men, while most participants had more than 11 years of teaching experience, which made it possible to evaluate the impact of the strategies implemented in a group with a consolidated track record in higher education.

In 2024, the institution implemented various strategies to strengthen the academic skills of teaching staff, achieving significant progress in all areas

evaluated. One of the most relevant initiatives was specialized training in educational inclusion, designed to provide teachers with pedagogical tools that would enable them to more effectively address diversity in the classroom. As a result, initial training in diversity awareness increased by 4.3%, reflecting a more solid preparation from the start of their teaching career.

Another key aspect was the promotion of continuous training through monthly workshops and seminars on educational regulations and inclusive methodologies. Thanks to this strategy, training in regulations experienced the highest growth, with an increase of 7.9%. In addition, 95% of teachers actively participated in these refresher programs, contributing to an average increase of 4.4% in their knowledge of international legislation and regulations.

To facilitate access to relevant information, new digital platforms and resources were incorporated, allowing teachers to expand their knowledge of educational inclusion. Through online courses and updated bibliographies, access to specialized resources grew by 4.4%, providing more appropriate materials to meet the needs of students. At the same time, inter-institutional collaboration networks were strengthened, promoting the exchange of good practices in inclusive education.

Finally, teacher training management was also optimized through the implementation of evaluation and monitoring plans, ensuring that the knowledge acquired was effectively applied in the classroom. This improvement was reflected in a 5.3% increase in this competency, consolidating the positive impact of the strategies implemented. In short, the strengthening of academic competencies was the result of a comprehensive approach that combined a process of ongoing training and access to new resources, promoting a more inclusive and higher quality education.

The results show significant progress in all aspects evaluated, reflecting the positive impact of the training strategies implemented. One of the most relevant achievements is the 19.6% increase in flexible programming for different learning styles, with an average that rose from 3.47 in 2023 to 4.15 in 2024. This indicates that teachers have improved their ability to structure activities that accommodate the diversity of learning rhythms and styles in the classroom.

Likewise, the adaptation of curriculum content showed an increase of 15.3%, raising its average from 3.73 to 4.30, which suggests that educators have acquired more effective tools to adapt content to the needs of students. Another area of notable progress is the diversification of activities, which grew by 15.4%, with the average rising from 3.90 to 4.50. This progress reflects that teachers

have incorporated more inclusive strategies, leaving behind homogeneous teaching approaches.

On the other hand, the use of inclusive and adaptive methodologies increased by 17.6%, which shows a greater implementation of pedagogical approaches that promote equity and active student participation. There was also a 16.5% increase in planning according to the level and context of the students, indicating that teachers have developed a greater sensitivity to adjusting their pedagogical strategies to the reality of their students.

Overall, the findings show significant progress in the teaching skills of teaching staff, confirming that training has been key to strengthening their preparation to design more inclusive classes. Among the most notable advances are flexible scheduling, the use of inclusive methodologies, and the diversification of activities, demonstrating a real commitment to equity in the classroom.

However, there are still areas that require further strengthening. For example, involvement in the design of teaching materials, although it showed an increase of 23.0%, remains one of the items with the lowest score in the 2024 evaluation. Similarly, preparation for educational transition, despite having improved by 20.3%, continues to represent a challenge within inclusive education.

These results confirm that teacher preparation strategies have had a positive impact, but they also highlight the need to continue with specific training in the design of adaptive teaching materials and in teacher preparation to accompany students in their educational transitions. Continuing to strengthen these aspects will be key to consolidating a truly inclusive teaching model in higher education.

The results show a significant improvement in the management of space and resources within the classroom, reflecting the positive impact of the strategies implemented over the last year. Of particular note are the increases in flexible grouping for special attention and the adaptation of spaces to improve inclusion, both with an increase of 19.4%. This suggests that effective measures have been implemented to optimize student distribution and improve the accessibility of educational spaces, promoting more equitable integration.

In addition, efficient time planning grew by 19.3%, indicating that teachers have improved the organization of pedagogical activities, allowing them to more effectively address the individual needs of their students. For its part, the use of flexible resources increased by 17.9%, reflecting the implementation of adaptive methodologies and the use of diversified materials that enrich inclusive learning. In the same vein, professional collaboration among teachers, with an

improvement of 18.0%, has been key to strengthening teamwork and promoting inclusive practices in the classroom.

In terms of infrastructure and accessibility, the use of external spaces for teaching grew by 14.7%, while school accessibility in infrastructure improved by 14.4%. Although these aspects have shown progress, their growth has been lower compared to other items evaluated, indicating that there is still room for improvement in the adequacy of physical spaces to ensure a more inclusive educational environment.

Time management in inclusive activities, with an average of 5.60 in 2024, is consolidated as the best-evaluated organizational competency, reflecting the success of the strategies implemented to optimize time in the classroom. Overall, the data confirms that the actions taken have had a positive impact on the organization of space and resources, promoting more equitable and accessible teaching for the entire educational community.

The results reflect significant progress in most of the aspects evaluated, indicating an improvement in teachers' preparedness to interact with their educational environment. One of the most notable achievements is the 20% increase in flexibility in collaboration, with an average that rose from 3.50 in 2023 to 4.20 in 2024. This suggests that teachers have developed a greater ability to adapt their communication to different contexts and needs.

Likewise, the planning of communication activities showed a significant improvement, reaching an average of 4.40 in 2024 compared to 3.90 in 2023. This growth reflects better structuring of strategies designed to encourage student participation. In addition, the promotion of student communication increased by 16%, indicating that more spaces have been created for students to express their ideas and opinions in the classroom, promoting greater inclusion and active participation.

However, collaboration among teachers showed more moderate growth compared to other aspects evaluated, suggesting the need to continue strengthening teamwork and communication among colleagues to consolidate truly inclusive and collaborative teaching. Overall, these results confirm the positive impact of the strategies implemented in the development of teachers' communication skills, promoting more participatory teaching. Nevertheless, it is advisable to continue strengthening training programs in communication and shared strategies, with the aim of optimizing teacher collaboration and improving joint work in the educational process.

The results show an improvement in the organizational skills evaluated in 2024 compared to 2023, with increases ranging from 3.75% to 5.26%. The most significant advances were recorded in the integration of students into groups and rational attention to diversity, both with a growth of 5.26%. This indicates that effective strategies have been implemented to promote inclusion and achieve equitable organization within the classroom.

Likewise, the use of prior knowledge experienced an increase of 5.13%, suggesting that teachers have strengthened their preparation to take advantage of students' prior learning and enhance their development. Progress was also observed in inclusive practice and conflict resolution facilitation, with a 4.65% increase, reflecting improvements in the application of inclusive methodologies and in the management of coexistence within the classroom.

Another relevant aspect is the use of inclusive technology, which showed a 4.90% increase, evidencing a greater effort in incorporating digital tools accessible to all students. However, psycho-pedagogical support and family involvement were the items with the lowest increase (4.02% and 3.75%, respectively), pointing to the need to strengthen collaboration between teachers, families, and specialists to improve educational support.

Overall, the data reflects sustained progress thanks to the strategies implemented. Nevertheless, there are still areas of opportunity that require greater attention in order to continue optimizing inclusive education within the institution. Strengthening family participation and psycho-pedagogical support will be key to consolidating more equitable and effective teaching for all students.

The implementation of various strategies to strengthen the assessment skills of teaching staff was reflected in an increase in all items evaluated compared to 2023. One of the most important initiatives was training in formative and differentiated assessment, where teachers participated in specialized workshops to more accurately identify students' individual needs. This explains the 4.78% increase in the ability to detect when a student needs guidance and in the assessment of prior knowledge before the start of classes, allowing for better adjustment of teaching strategies from the beginning of the educational process.

Another key strategy was the incorporation of new assessment tools, promoting the use of rubrics, digital portfolios, and adaptive questionnaires to evaluate student performance more equitably. As a result, the use of different assessment methods grew by 4.86%, indicating that teachers have diversified their tools for measuring learning. Likewise, effective feedback increased by 4.44%, thanks to

the application of strategies such as personalized feedback and the use of digital platforms to monitor student performance.

In addition, a more flexible and diversity-friendly assessment was promoted, encouraging tests tailored to students' different learning paces. This explains the 3.44% growth in the use of flexible assessment methods and the 3.98% growth in the application of adapted individual assessments. Although these advances are positive, there is still room to strengthen the personalization of assessment through approaches such as project-based learning and guided self-assessment.

On the other hand, the importance of ethics in assessment was emphasized, ensuring objective and transparent grading criteria. As a result, there was a 3.95% improvement in ethical integrity in assessment, reflecting a greater commitment by teachers to fair and equitable practices. However, practical and functional learning showed more moderate growth (1.79%), suggesting that it already had a high level of implementation, although it can still be optimized with approaches that prioritize the applicability of knowledge in real contexts.

Conclusions

The results of this study reflect significant progress in teacher training in inclusive education, with improvements in all dimensions evaluated. In particular, teaching, organizational, and communication skills have shown remarkable progress, demonstrating that teachers are better prepared to adapt content, diversify teaching strategies, and manage the classroom more effectively to address diversity. The implementation of inclusive methodologies, the use of flexible resources, and better time management have been key to building a more equitable and accessible learning environment for all students.

Despite these advances, challenges remain that require attention, such as strengthening collaborative work among teachers, greater involvement of families, and improving accessibility in school infrastructure. Although progress has been made in integrating inclusive technologies and optimizing communication, it is essential to continue expanding training in differentiated assessment, the design of adaptive materials, and educational transition strategies. In addition, promoting spaces for the exchange of good practices, strengthening psycho-pedagogical guidance, and ensuring adequate physical environments will be essential aspects for consolidating a truly inclusive educational model.

These findings confirm that teacher training in inclusive education is transforming teaching practice and contributing to the construction of a more equitable educational system. However, for these advances to be sustained over time, it is

crucial to adopt a continuous improvement approach, ensuring that strategies, training, and resources evolve in line with the needs of students and the educational context. Only through a firm commitment to equity and diversity can we guarantee quality education for all.

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The hidden risks of information and communication technologies in education: university students' perceptions

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Introduction

In recent years, discourses about Information and Communication Technologies (ICT) in education have been largely shaped by optimistic narratives, particularly those advanced by governments and major technology corporations (Mesquita *et al.*, 2022), especially after the COVID-19 pandemic. These actors often portray ICT as a transformative force capable of solving structural problems in education, which has led to rushed investments and inflated expectations (Saura *et al.*, 2022). However, research shows that access to technology and its mere use do not necessarily translate into meaningful improvements in learning outcomes, and in some contexts, may even produce adverse effects such as distraction, demotivation, or academic underperformance (Fernandez *et al.*, 2020).

Despite these findings, a technocentric and uncritical perspective persists (particularly in higher education), where both students and teachers may normalize problematic uses of digital tools. This orientation often undermines pedagogical reflection and contributes to the neglect of risks such as digital fatigue, surveillance, and privacy violations. In the abscense of critical awareness, students remain particularly vulnerable to these issues (Rodríguez *et al.*, 2025). Therefore, it is crucial not only to promote the educational potential of ICT but also to foster critical understanding of its limitations and unintended consequences (Giménez, 2021).

Although users may choose how to use these tools, their capacity for discernment can be limited if they lack a clear understanding of their implications. The overvaluation of ICT advantages and the invisibilization of their risks increase students' vulnerability to cognitive distraction, digital fatigue, and

the loss of data privacy in digital environments.

Within this framework, the main objective of this study is to explore university students' perceptions of the benefits attributed to ICT for their learning, as opposed to the risks associated with its misguided use in relation to their academic performance. The specific objectives of the study are as follows: to explore university students' awareness that using ICT in education may involve both benefits and risks for their academic performance; to identify the main benefits and risks students associate with ICT use in education; and to identify less recognized benefits and risks that may pose vulnerabilities in students' academic development.

A total of thirty-seven students participated in the study on a voluntary basis, including twenty-one women and sixteen men. All participants were already acquainted with one another, as they had previously shared other courses during their academic journey at the university.

The activity was part of a three-week didactic sequence focused on the critical analysis of the role of technology in education. In the first week, during a face-to-face session, students analyzed a case study illustrating the tension arising from the introduction of technology in a rural community and the resistance expressed by some residents concerned about potential cultural changes. Based on this scenario, students reflected on the benefits and risks of technology use, considering its social implications.

In the second week, the discussion shifted to the context of formal education. The activity was conducted through an asynchronous virtual forum, where students responded to the following guiding question: What are the main benefits and risks you perceive in the use of ICT for your learning? During the third week, students created infographics in which they synthesized recommendations for addressing the risks associated with previously identified uses of ICT. For the purposes of this study, the analysis focused exclusively on students' contributions made in the asynchronous virtual forums.

An initial coding protocol was developed based on a literature review on perceptions of benefits and risks associated with the use of ICT in education. This protocol underwent an iterative refinement process. As the data were reviewed, some codes were adjusted and new ones were incorporated, depending on the characteristics and emergent nature of the content.

Based on the work of Castellanos and Niño (2020), this study used the message fragment as the unit of analysis. This methodological decision was based on the observation that, within a single student message or turn, it was common to find

multiple references, either to distinct benefits or to various risks related to the use of ICT. The final version of the coding protocol is presented in Table 1.

Table 1. *Codes for identifying the benefits (B) and risks (R) of ICT in education*

Codes	Description
B_1	Improves comprehension, organization, or follow-up by enhancing learning flow.
B_2	Simplifies or automates the completion of academic tasks.
B_3	Facilitates academic content search, access, and consultation.
B_4	Improves teacher-student interaction.
B_5	Reduces errors, saves time, or improves the academic work.
B_6	Enhances technological, cognitive, or communication skills.
B_7	Increases interest, attention, or enthusiasm in learning.
R_1	Concerns about data misuse, exposure to harmful content, platform insecurity, or cyberbullying.
R_2	Effects of excessive ICT use on habits or social interaction.
R_3	Negative learning impacts, such as cheating, low cognitive effort, or diminished critical thinking.
R_4	Structural or technical barriers, such as lack of connectivity, devices, digital skills, or financial resources.
R_5	Spread of false or irrelevant content and its effect on judgment and evidence-based learning.
R_6	Physical or emotional strain from ICT use.

A total of 291 message fragments were coded. Of these, 65% correspond to students' perceptions of the benefits attributed to the use of ICT. Table 2 presents the number of students who identified different numbers of perceived benefits (from a total of seven categories) and risks (from a total of six). It shows how many students reached each level of perception in each dimension. The values for benefits and risks are not comparable row by row, as they reflect independent distributions.

Table 2. *Distribution of students by number of ICT-related benefits and risks identified*

Number identified	Number of students	
	Benefits	Risks
6	6	2
5	30	0
4	1	0
3	0	19
2	0	16
Total	37	37

Of the 37 participating students, 36 identified between five and six benefits related to the use of ICT. In contrast, a lower level of risk recognition was observed. Most students (35) mentioned only two or three risks, and only two students identified six risks related to the uncritical use of these technologies.

This contrast reveals a higher level of recognition of benefits compared to risks. Students appear to be more familiar with the functional advantages of ICT, whereas negative effects tend to go unnoticed or be underestimated.

As part of the content analysis, different types of benefits and risks attributed to the use of ICT in education were identified. Table 3 presents the frequencies of message fragments coded within each category.

Table 3. *Frequencies of perceived benefits and risks of ICT by typology*

Types of Benefits	f	Types of Risks	f
B_1	12	R_1	11
B_2	42	R_2	23
B_3	61	R_3	26
B_4	16	R_4	20
B_5	23	R_5	12
B_6	25	R_6	9
B_7	11	-	-

The most frequently mentioned benefit by university students was the ease of accessing and obtaining information (B_3), with a total of 61 coded fragments. For many students, this functionality constitutes an essential component of academic life, as the internet enables them to search for and consult content relevant to their classes and assignments. The following message fragment illustrates a student's perception of the internet as an essential part of academic life:

> The internet is extremely important to me; I can't imagine my life as a student without being able to use it. I use it every day to search for information on the topics we cover in class. That's really its main use for me (Student 12).

The second most frequently mentioned benefit corresponds to the workflow simplification provided by ICT (B_2), with 42 message fragments. Students

perceive that digital tools, especially those based on artificial intelligence, simplify and automate tasks that previously required greater effort. For example, a student noted: "To make presentations, I use Canva because it gives me the templates, and from there it's easier to put a presentation together" (Student 8). Another explained: "I used to take notes in my notebook, and then I couldn't even understand them myself; now with my cellphone it's easier I can record the entire class" (Student 9).

To a lesser extent, some students recognize that ICT contributes to improving efficiency and accuracy in task completion (B_5), as reflected in 23 coded fragments. The following message fragment illustrates how technology supports error detection and enhances the quality of students' assignments: "When I finish an assignment, I make sure to use the spell checker to catch any mistakes. I discovered that option recently, and now I use it all the time" (Student 16).

A total of 25 message fragments were also identified referring to skill development (B_6), particularly in relation to technological and adaptive skills. In the following example, a student highlights how the constant use of digital tools compels them to stay up to date, which leads to the development of new technological skills: "I always end up learning something new. Technology moves fast, and even if I use the same tool, they keep adding new features. That forces me to stay up to date" (Student 2).

In contrast, the least frequently mentioned benefits were improvements in academic communication channels (B_4, 16 fragments), enhancement of the educational process in terms of comprehension and learning organization (B_1, 12 fragments), and motivation for learning (B_7, 11 fragments).

This suggests that, although these aspects are frequently emphasized in current discourse on ICT in education, students do not identify them as clearly. This may point to a gap between technocentric approaches that promote ICT as tools for transforming the educational experience and the everyday, task-oriented ways in which students actually use them.

Regarding the risks perceived by students, the most prominent one is related to academic issues (R_3), with a total of 26 coded message fragments. Participants acknowledge that excessive use of ICT can diminish their critical thinking and cognitive effort, especially when they become accustomed to copying and pasting information without engaging in any form of analysis. For example, a student noted: "Having so many ways to access information creates the bad habit of expecting automatic answers, but I sometimes wonder if, in the long run, that could affect the ability to think" (Student 5).

The second most frequently mentioned risk among students is dependency and behavioral changes associated with excessive ICT uses (R_2), with 23 fragments. Students report that social media often distracts them when trying to complete assignments, and they express concern about the contrast between their activity in digital environments and their in-person social lives. The following is a message fragment in which a student describes a personal experience:

> I tend to procrastinate a lot when I'm in front of a screen, and sometimes I get really frustrated... One time I had to shut down all my social media just to be able to make progress on my final assignments. That time I felt like I was going to fail the semester (Student 13).

Another frequently identified risk is inequality and technical limitations (R_4), with 20 coded fragments. Some students acknowledge that not everyone has the same technological conditions, which can limit their academic performance. The following message fragment reflects this type of perception: "Sometimes I feel limited because, even if I want to do more, I can't my computer is on its last legs. That's why I say it's a risk: not all of us have the same conditions" (Student 6).

In contrast, the least frequently mentioned risks were those related to information security and privacy (R_1, 11 fragments), misinformation (R_5, 12 fragments), and the physical or emotional health effects of intensive technology use (R_6, 9 fragments). These risks may not be perceived as immediate threats to students' everyday academic routines, which increases their vulnerability. As a result, they may fall into digital practices, such as sharing sensitive data or developing unhealthy technology-related habits, without being fully aware of the consequences.

Conclusions

Based on the objectives established for this study and the findings obtained, three key conclusions can be drawn. First, there is a clear imbalance in students' perceptions: while most easily identify the benefits of ICT for their academic development, the associated risks are often overlooked or insufficiently recognized, typically limited to just two or three latent concerns. This imbalance likely reflects the influence of technocentric discourses in education and media, where technology companies promote innovation and learning improvement without solid empirical backing (Selwyn, 2022). Institutional policies may reinforce this optimistic view by prioritizing digital adoption over critical reflection, leaving the risks of inappropriate use beyond the scope of students' educational formation. In this context, schools must play a more active role in fostering critical engagement, not just teaching how to use digital tools, but how

to think with and through them (Mesquita *et al.*, 2022).

Second, the benefits students attribute to ICT are mostly practical: quick access to information, ease of completing tasks, and improved efficiency. Few students link ICT use to enhanced understanding or cognitive development. While they value speed and convenience, they rarely perceive a meaningful impact on learning itself. This supports findings by Niño *et al*. (2025), who observed that students associate technology with task acceleration, but not necessarily with deeper learning or problem-solving. Time is saved but learning gains are not always clear.

Finally, students tend to minimize risks related to digital security and data privacy, likely due to the trust they place in institutional platforms. As Rivera *et al*. (2024) note, many students feel protected when using university systems and associate risk mainly with external platforms. However, trust in institutions does not ensure effective protection. Li *et al*. (2023) report that data breaches and privacy violations are increasingly common in universities, which are frequent cyberattack targets due to their extensive data management and shared networks. This is further compounded by students' limited training in protecting their digital identity and personal information.

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Continuing education for university teachers from a Science, Technology, and Society (CTS) perspective in the Ecuadorian context

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Continuing education for university teachers: an initial perspective

For González, continuing education for teachers should be conceived as a flexible and contextualized educational process (González and González, 2007, p. 10). Thus, learning after initial education, in which teachers can receive updates and elements to develop their professional practice.

Continuing education is a tool that encourages people to remain prepared and seek professional development to improve their competitiveness in the workplace (Moreno, 2021).

Villegas (2003), Aguerrondo (2004), Ávalos (2007), Añorga (2007), Vaillant (2009), Terigi (2010), among others, define it as a process that is constantly changing, allowing for an increase in the quality of education.

Teacher training: from imagination to reality.

When referring to teacher training, traditionally, the first thought that comes to mind is that it can be understood as something that teachers must consciously take on personally, being clear that in their profession, their training is part of their responsibility. This idea has been strongly influenced over time by the myth that overvalues vocation (teachers are born, not made), minimizing training, to which are added the myths of the multifunctional teacher (because they are

teachers, they possess skills specific to other professions) and, combined with both myths, the myth of being omniscient. (De Oliveira, 2005)

However, in real, everyday life, society witnesses teachers constantly studying, observing their environment, and taking from it what they need to fulfill their task. This observation of reality helps us understand that the ongoing training of university teachers is a personal and professional responsibility, as their work requires constant updating in line with changes in their environment (Fernandes and Gouvêa, 2019).

But it is not enough to address shortcomings and challenges; it is also necessary to incorporate advances, new knowledge, and trends that arise on a daily basis. However, this training cannot depend solely on individual initiative. It must be coordinated with national education policies and institutional guidelines, ensuring a systematic process that guarantees educational quality and the development of teacher training within an organized and structured framework (Lacueva, 2015).

It is therefore well known that the continuing education of university teachers must be approached from the perspective of internal policies defined by educational institutions. Avello, et al. (2014). This requirement will encourage teachers to take the lead. Feeling the support of their institution, they will be motivated to identify, based on their own practice, the training needs required to address those identified in society and the environment. By mutual agreement, they will define the guidelines and actions that should guide training plans, based on a current vision of the teacher's own learning process. Granados et al. (2017)

This procedural idea will help to fulfill what UNESCO considers a duty: "to adopt an integrated and lifelong learning approach to education for the achievement of Sustainable Development Goal (SDG) 4 (...) by providing quality training and continuous professional development for teachers." UNESCO (2024)

The guidelines issued by the aforementioned international organization are supported in Ecuador by the Organic Law on Higher Education (LOES), which establishes that it is the duty of teachers and researchers, in accordance with the Constitution and this Law, to maintain a permanent process of training and capacity building for the constant updating of teaching and the achievement of the principle of quality... (LOES, 2020, Art. 6.1 p.14)

But all this is still not enough. Both teachers and the national or institutional policies established for their training need to have access to continuous training that includes the introduction of updated content on advances in science and

technology in society, so that teachers not only transform the content taught in universities, but also redefine the methodologies and tools used for teaching (Domiciano and Lorenzetti, 2020). .

The challenges of science and technology that require the updating of continuing education for university teachers

Currently, everyday life shows students to be skilled in the use of different technological devices such as mobile phones, tablets, and computers, and in their mastery of social networks such as Facebook, Instagram, YouTube, among others. Children and young people are fascinated by this technology, and, above all, access to entertainment games and increased communicative interaction with friends take up an excessive amount of their time (Escalona and Fontal, 2007).

This concern is reflected in various publications showing measures to ban this technology in the hands of students in some institutions. Tapia (2025) addressed the issue of prohibition, citing UNESCO as an example: "By the end of 2023, 60 education systems (or 30%) had bans on the use of smartphones in schools in their laws or policies. By the end of 2024, an update to the report revealed that 19 more education systems were banning the use of smartphones in schools, bringing the total to 79 (or 40%)."

Some Spanish institutions have also implemented the ban, and Álvarez et al. (2024) offer arguments for the consequences of taking such a measure:

- Social impact of mobile phones: Mobile phones in everyday life affect both adults and young people. Their excessive use generates family concerns, conflicts, and social problems such as cyberbullying.

- Consequences of excessive use: Overexposure to screens causes sedentary lifestyles, addiction, and digital stress with consequences for young people's health, including addictive behaviors on the internet.

- Need for regulation: Several studies recommend establishing clear rules on mobile phone use in educational centers to avoid distractions and maximize their educational potential.

- Prohibition vs. educational use: There are divided opinions on banning cell phones in classrooms. Some countries have implemented restrictions, while others promote their educational use with proper management.

With regard to Latin America, this is exemplified by some Brazilian institutions, where, according to Dos Santos, CR. et al., (2020):

measures such as meetings with the school community, the signing of a commitment agreement by parents, the intervention of the Juvenile Court, and teacher supervision of mobile phone use during classes were well received by the institution. (p.3)

The above makes it clear that technological advances and their widespread use among young people pose a challenge for teachers: to integrate these resources effectively into the classroom. Far from being a distraction, the use of mobile phones and other technologies can become a valuable tool if educators have the necessary knowledge to design strategies that promote dynamic and meaningful learning (Díaz et al, 2023).

Therefore, teacher training cannot be limited to their discipline, but must include the development of digital skills that enable them to use technological tools with clear pedagogical objectives.

The digital transformation in education requires teachers to develop skills to take advantage of technological tools with innovative pedagogical approaches. Gamification, for example, makes it possible to turn learning into an interactive and motivating experience, adapted to the dynamics of student participation. Through the use of educational platforms, simulations, and game strategies, teachers can foster creativity, critical thinking, and engagement in the classroom (Núñez, 2023).

Innovation from the CTS approach: the necessary digital culture

Continuing education for university teachers with a focus on Science, Technology, and Society (CTS) allows us to understand that technological advances not only transform the production of knowledge, but also the way it is taught and learned. In this sense, methodologies such as gamification are presented as an educational response aligned with social and technological changes, allowing teachers to adapt their teaching strategies to new digital environments (Badeo et al., 2024).

To achieve this, it is essential that teacher training includes knowledge and application of these methodologies, ensuring that technology becomes an active resource for enhancing teaching.

Regarding this need, seen as a challenge, Piraval et al. (2013:5) recognize that teachers must create learning situations, such as moments, spaces, and environments organized by the teacher to carry out a series of learning, assessment, and teaching activities that stimulate the construction of meaningful learning.

Various pedagogical strategies provide the content for these situations that can enrich and promote active and meaningful learning. These include debate-style lectures and post-class information sessions, as well as the creation of learning communities. Pachacama, Villacrés, Carlín & Maliza (2025:196).

It is under these conditions that teachers, if they are aware of scientific and technological advances, can innovate in their classrooms, because they can introduce these technological advances into their teaching process.

In the field of education, innovation implies a transformation that responds to a meaning and has an implication, a vision, and an ultimate goal, which in this case is to achieve the quality education demanded by the SDGs, because it will be more in line with the times (Barrero, 2014, p. 2).

In the case of higher education, innovation is an intentional and ongoing process within the educational institution. Its purpose is to bring about real and positive transformations and impacts on three fundamental elements in students: learning, environment, and culture (Romero and Simaluiza, 2019).

Such innovation processes will be possible because technology has changed the way young people interact with knowledge, moving from being passive recipients to active builders of their learning, and teachers cannot be oblivious to this. According to Arias (2016:300), teachers must have a digital culture that encompasses basic educational digital skills, starting with the proper use of ICTs, knowing how to provide personalized instruction based on the individual differences of the learner, and learning about the diversity of cultures that exist through the use of search platforms.

All of this learning, updated through the continuous training of university teachers, will enable teachers to guide students on the path to acquiring knowledge (Campí et al., 2020).

These statements reflect the innovative representation of the digital age we live in, because 21st-century students take on a new role, as characterized by researchers Paredes et al. (2021, p. 340):

a. Center and main actor in the teaching-learning process

b. Skilled information manager

c. Autonomous in the construction of knowledge

d. Active in spaces of cooperation and collaboration and, through them, achieving meaningful learning.

Understanding the above leads to incorporating these scientific and technological advances into the classroom to strengthen the link between education and everyday reality, creating dynamic experiences that take advantage of digital devices and platforms for educational purposes. Ignoring this evolution could mean a disconnect between teachers and students.

Science, Technology, and Society: an essential approach in the continuing education of university teachers

Scientific and technological advances not only transform the content taught in universities, but also redefine the methodologies and tools used for teaching.

A teacher who is well trained in Science, Technology, and Society (CTS) understands that scientific knowledge is neither static nor neutral, but is linked to social, economic, and cultural dynamics. For example, the rise of artificial intelligence (AI) in education is not only a technical advance, but also a phenomenon that raises ethical and pedagogical challenges (Alvarado et al., 2012).

To address these challenges, the continuing education of university teachers must integrate these discussions so that educators not only use technology but also analyze its implications for teaching and learning.

By responding to the real needs of society, teachers who incorporate STS into their continuing education not only acquire new digital skills, but also reflect on how these tools can improve educational equity and access to knowledge. In other words, STS training seeks not only to update knowledge, but also to develop a critical awareness of the role of science and technology in social progress.

In this way, it can be understood that the creation of dynamic experiences from this perspective requires up-to-date continuing education, with media literacy actions that not only promote access to the media, but also transcend the concept of verbal and literacy literacy. (Pérez Ortega, 2017, p. 250). This is a call for the continuous training of teachers to include the development of digital teaching skills so that, according to Paredes et al. (2021), teachers develop skills that enable professionals to adapt to technological changes and changes in relationships between individuals, as well as to make appropriate use of information. (p. 341)

Theoretical Basis of the Science, Technology, and Society (CTS) Approach

As can be seen in the previous sections, the CTS approach proposes an integrative view of science and technology in relation to society, promoting a

critical and contextualized understanding of scientific and technological advances. This approach emphasizes the importance of training teachers who are capable of reflecting on the social impact of science and technology and incorporating this reflection into their teaching practice. In the context of higher education, the STS approach facilitates the training of professionals committed to sustainable development and social innovation.

The Science, Technology, and Society (CTS) approach emerged as a transdisciplinary field of study and research that critically examines the complex interrelationships between scientific and technological development and the social, cultural, economic, political, and ethical context in which it is produced and applied, with a focus on its implications for education (CTS Approach in Teaching), from the educational objective of training scientifically and technologically literate citizens, capable of understanding CTS interrelationships, for informed and responsible decision-making in their personal lives and as members of society (Akcay and Yager, 2010).

The promotion of curriculum content that addresses the inclusion of socially relevant and controversial topics (e.g., climate change, genetic engineering, artificial intelligence, waste management, public health), the analysis of the nature of science and technology, and the history and philosophy of science. All of this an understanding of the role of the teacher, whose role should be more that of a facilitator of learning and critical thinking than a mere transmitter of knowledge. Teachers must be able to manage discussions on complex and often value-laden topics.

In the context of the 21st century, the CTS approach is more relevant than ever. Global challenges such as the climate crisis, pandemics, digital transformation, artificial intelligence, food security, and the need for sustainable development require a deep understanding of STA dynamics. The use of technological tools can promote the creation of reflective activities that support the development of critical thinking, interactivity, collaboration, and teamwork.

Ecuador faces the challenge of using a technological approach in the continuing education of university teachers

For a country like Ecuador, this approach is crucial, given the need to orient scientific and technological development towards solving local and national problems (health, agriculture, environment, energy, infrastructure). Along the same lines, there is a need to promote innovation in a socially responsible and environmentally sustainable manner, which entails fostering a critical and participatory citizenry in decisions about the country's technological and scientific direction, with the adaptation and appropriation of new technologies

in a way that benefits society equitably, taking into account cultural and socioeconomic particularities. This requires the continuous training of university teachers with a comprehensive vision, capable of anticipating and managing the social and ethical impacts of their work.

From this perspective, scientific and technological progress should not be considered an end in itself, but should be analyzed and directed taking into account its effects on society and the natural environment. As Acevedo Díaz and colleagues explain, the Science-Technology-Society (CTS) approach is distinguished by its interdisciplinary nature, its interest in placing science and technology within a social context, and its attention to the ethical and political dimensions of scientific and technological advances (Acevedo Díaz et al., 2005).

One of the key theoretical foundations of the STS approach is the idea that scientific and technological knowledge is socially constructed. This means that neither scientific theories nor technological devices arise in isolation, but are deeply influenced by the values, beliefs, interests, and power relations present in a society. This view challenges the traditional conception of science as a purely objective search for truth by emphasizing how social factors influence what is recognized as legitimate knowledge or appropriate technology. From this perspective, the social constructivist theory of technology (SCOT) argues that the final design of a technology is the result of interactions, interpretations, and negotiations between different social groups involved (Bijker et al., 1987).

Finally, the STS approach advocates for critical scientific and technological literacy aimed at citizens. This goes beyond simply understanding scientific concepts or how devices work, as it seeks to educate people to reflect on the social, ethical, and ecological consequences of science and technology. It also promotes active and informed participation in decisions that directly affect everyday life. In this sense, scientific and technological literacy from the perspective of the STS approach aims to empower citizens so that they can contribute to the construction of a more equitable and sustainable society (Aikenhead, 2009).

In summary, the theoretical foundation of the STS approach provides a robust and critical framework for analyzing and acting on the complex and dynamic relationship between science, technology, and society, with the ultimate goal of guiding scientific and technological development toward human well-being and sustainability.

The contextualization of the STS approach in the continuing education of university teachers: critical thinking, digital literacy, and the social impacts of science

Continuing education based on the STS approach favors the introduction of different strategies in the classroom, because it allows for the proposal of teaching processes capable of working with multidimensional factors that converge in the techno-scientific construction of knowledge.

Among these are critical thinking and the analysis of the social impacts of science, which facilitate the design of reflective, interactive, collaborative, and teamwork activities.

These include critical thinking and the analysis of the social impacts of science, which facilitate the design of reflective, interactive, collaborative, and teamwork activities. However, especially in these times, if teachers continue their training with constant updates to their digital literacy

Critical thinking

The promotion of critical thinking is presented as a central axis to enrich the continuous training of teachers within the Science, Technology, and Society (CTS) approach, because it allows teachers to reflect deeply on the complex relationships between science, technology, and society, while giving them tools to cultivate this ability in their students. Teacher training focused on this area would enable them to question assumptions, analyze evidence, and construct solid arguments around socio-scientific issues. point out, this skill is essential for understanding and participating in an informed manner in matters related to science and technology (Norris, 1985).

From the STS perspective, ongoing training aimed at developing critical thinking could include strategies for critically evaluating sources of scientific and technological information, recognizing possible biases, and assessing the soundness of arguments circulating in public discourse on issues such as climate change, genetic modification, or artificial intelligence. In this way, teachers would be better prepared to accompany their students in the construction of well-founded opinions, promoting active, reflective, and committed citizenship. In the words of Hodson (2003), the ability to critically analyze information related to science and technology is key to effective STS literacy.

Integrating critical thinking as a cross-cutting component in continuing teacher training from an STS perspective would not only strengthen their understanding of the interactions between science, technology, and society, but also enable them to develop in their students the skills necessary to face the challenges of

an environment increasingly marked by technological and scientific advances. This integration can be achieved through various methodologies such as workshops, seminars, and practical activities focused on reflection, debate, and analysis of real-life situations. As Driver et al. (2000) state, encouraging critical thinking in science and technology education is key to training citizens capable of making responsible decisions.

Digital literacy - Application of educational technology - Learning analytics

Digital literacy, the pedagogical use of technologies, and learning analytics are topics with great transformative potential for continuing teacher training from the perspective of the Science, Technology, and Society (CTS) approach.

Digital literacy, understood not only as the ability to use technological tools, but also as the ability to critically interpret the digital environment and understand its social implications, is key in a reality where science and technology are strongly influenced by digital technology. In this sense, continuing education programs could focus on teaching how to evaluate the reliability of scientific information available on the internet, how to use digital technologies to improve collaboration and communication, and how to critically analyze the social and ethical effects of these technologies. As Gilster (1997) argues, digital literacy is an essential skill for functioning adequately in today's society, which includes the ability to critically interpret scientific and technological information online.

On the other hand, integrating educational technology from a CTS perspective involves more than just incorporating devices or platforms into the classroom; it requires reflection on how these technologies can enhance active learning, critical thinking, problem solving with social and scientific dimensions, and a greater understanding of the relationships between science, technology, and society. Teacher training could include experiences with interactive simulators to explain scientific phenomena, digital forums to discuss ethical dilemmas related to technological advances, or tools for developing collaborative projects focused on local social issues from a CTS approach.

According to Bautista et al. (2006), the thoughtful use of educational technology can significantly enrich science teaching and learning within the STS framework, promoting active participation and deeper understanding.

Finally, learning analytics provides the possibility of collecting and analyzing relevant data on how teachers learn during their continuing education, which allows training processes to be tailored to their specific needs. By monitoring aspects such as interaction with content, level of participation, and pace of progress, it is possible to identify both strengths and areas for improvement and

to design more personalized and effective training proposals. Applied within the STS approach, learning analytics can provide useful information on how teachers develop critical skills in relation to STS topics or how they integrate this approach into their methodologies. As Siemens (2010) states, this tool can offer meaningful feedback to increase the quality and impact of teacher training programs.

Understanding the social impacts of science

Understanding the social impacts of science is a fundamental axis for enriching the continuing education of teachers from the perspective of the Science, Technology, and Society (CTS) approach. This approach proposes that teachers develop a critical awareness of how science and technology affect society and, in turn, how social dynamics influence scientific and technological development.

Continuing education for university teachers in this area could include the analysis of the ethical, political, economic, and cultural aspects associated with technological and scientific advances, thus enabling educators to address these issues in the classroom with a reflective and critical eye. As Bybee (1993) points out, STEM education should prepare students to understand and actively participate in the resolution of social issues related to science and technology.

In this vein, continuing education for teachers could focus on the study of real situations in which scientific knowledge and technological development have generated significant social effects, both beneficial and problematic. Relevant examples could be the social impact of the industrial revolution, the ethical dilemmas surrounding biotechnology, or the effects of digital technologies on everyday life, privacy, and democratic participation. Analyzing these cases would enable teachers to acquire tools to guide their students in reflecting on the present and future impacts of science on society. As Aikenhead (1985) points out, it is essential that tomorrow's citizens understand that decisions in science and technology are deeply linked to human values and social consequences.

Consequently, incorporating reflection on the social impacts of science into continuing education, from a STS perspective, would not only update teachers' knowledge but also contribute to a more critical, comprehensive, and integrative view of scientific and technological processes.

This perspective would enable teachers to promote a socially conscious attitude among their students, as well as a willingness to actively participate in discussions and decisions related to science and technology. In this way, science education would contribute to shaping more informed, critical individuals who are committed to building a more just and sustainable future.

As Hodson (2011) states, science education with a CTS approach seeks to empower students to act responsibly in the face of the challenges posed by today's techno-scientific world.

Design of contextualized activities with STS

The development of contextualized teaching activities based on the Science, Technology, and Society (STS) approach is presented as an effective pedagogical strategy for enhancing the continuing education of university teachers. By linking learning to real-life situations and issues in the environment, such as the specific environmental challenges of Guayaquil or the effects of technology on the daily life of the local population, a deeper and more relevant understanding of scientific and technological content is achieved (Marcillo and Vásquez, 2017).

This methodology not only increases teacher motivation by connecting knowledge to their immediate reality, but also promotes critical thinking and the ability to examine the complex relationships between science, technology, and society (Acevedo Díaz, 2004).

To address the Guayaquil context, teachers must have prior training in the environmental problems of these areas. This will enable them to develop activities that include topics such as urban solid waste management and its ecological impact, the evaluation of the water quality of the Guayas River and the technologies associated with its treatment, or the use of renewable energies in coastal areas.

These identified problems, linked to the environment, climate change, and their influence on society, are topics that offer the opportunity to address both the scientific fundamentals involved and the existing or emerging technologies that can contribute to solving these problems, while also considering their social, economic, and ethical dimensions. Working with these local scenarios allows teachers to design educational strategies that promote active student participation and the generation of responsible and contextualized solutions (Solbes and Vilches, 2004).

The incorporation of the STS approach into continuing education not only enriches teachers' knowledge, but also prepares them to create more relevant and meaningful learning experiences for their students. This perspective allows them to approach content from a perspective that recognizes the interactions between science, technology, and the social environment, thus facilitating the development of a scientifically informed and committed citizenry. It is not only a matter of transmitting scientific content, but also of encouraging critical

reflection on the consequences of technological advances and cultivating responsible attitudes toward both local and global social and environmental challenges (Fourez, 1994).

The lack of an STS approach in teacher training limits educators' ability to promote critical and contextualized teaching. It is imperative that higher education institutions in Ecuador review and update their continuing education programs, incorporating the STS approach to prepare teachers to face the challenges of a society in constant technological and scientific transformation.

Conclusions

The Science, Technology, and Society (CTS) approach is a fundamental basis for the continuing education of university teachers, particularly in the Ecuadorian context. This approach promotes a critical and situated understanding of science and technology in their interaction with society, training teachers who not only transmit content but also promote reflection on the social, ethical, and environmental consequences of scientific and technological progress.

In Ecuador, adopting this perspective is key to orienting scientific and technological development toward the resolution of local problems, promoting innovation with social responsibility, and training citizens to be critical and committed to decisions that affect the scientific and technological direction of the country.

Implement mechanisms for evaluating and monitoring continuing education programs to ensure their effectiveness and relevance.

Continuing education for university faculty in Ecuador faces significant challenges, ranging from the absence of programs that adequately incorporate scientific and technological advances to insufficient pedagogical preparation for the use of digital environments and the low value placed on this training in their professional careers. To overcome these limitations, including technophobia and the difficulty in applying learning analytics, it is necessary to develop training proposals that are flexible, contextualized, and in line with the real demands of teaching. Likewise, it is necessary to establish policies that recognize and encourage the active participation of teachers in their own professional development, with the aim of strengthening the quality of higher education in the country.

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Modern techniques for sustainable pitahaya production

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Introduction

Agricultural sustainability requires methodological approaches that go beyond simply compiling traditional practices. It is essential to integrate technical analysis with social, economic, and environmental impacts in order to generate useful knowledge in real production contexts. In this regard, the social sciences have emphasized the need for structured, empirical research aimed at territorial transformation and capable of contributing to more sustainable production models (Barros & Bores).

This methodological logic is especially relevant for emerging crops such as pitahaya, which require innovative production strategies adapted to current agroecological challenges. The cultivation of pitahaya, also known as dragon fruit, has gained commercial relevance in recent years at the international level, thanks to its organoleptic properties, nutritional value, safety, and high adaptability to different agroclimatic conditions.

These characteristics, together with its potential as an alternative crop in tropical and subtropical areas, position it as a strategic option within agricultural systems oriented towards sustainability (Verona-Ruiz et al., 2020; Pereira Da Silva Brito et al., 2024; Vera et al., 2021).

Due to the growth in pitahaya production, there is increasing interest in researching agronomic practices that can improve its cultivation. Some of the most important agronomic practices include how cladodes are managed, irrigation systems, fertilization methods, pruning, and pests and diseases. Pereira Da Silva Brito et al. (2024) explain that the location and size of cladodes directly impact fruit quality and production. In contrast, research by Nerd et al. (2002)

showed that plants do not do well in extreme temperatures because they increase flowering and cause a decrease in productivity.

All this implies that pitahaya productivity depends not only on factors associated with field cultivation, but also on post-harvest handling of the product. These factors and others, such as the degree of ripeness at the time of harvest and storage conditions, determine how good the fruit quality can be (Vera et al., 2021). To this must be added the technologies implemented, such as the use of non-renewable energies, which in fact contribute to energy efficiency. For example, in Puerto Pitahaya, Ecuador, innovations such as solar energy through photovoltaics have been tested (Pesantez et al., 2021).

Often, in addition to purely technical aspects, the issue of crop sustainability using a circular approach has been raised. For example, Diéguez-Santana et al. (2022) have described an assessment of environmental impacts and opportunities for the circular economy in agricultural systems. Therefore, pitahaya can be considered not only a profitable crop but also an alternative species for the introduction of broader agroecological systems.

On the other hand, from a plant health perspective, diseases that attack Hylocereus species, such as those reported by Balendres & Bengoa, are a factor that can limit production sustainability, as they reduce yields and require measures based on integrated management strategies. In this regard, the selection of adapted genotypes and the use of sustainable production practices have been proposed as measures to increase production and achieve plants that are more resistant to high levels of vulnerability (Betancur et al., 2020; Castillo et al., 2023).

Despite the progress observed in the production and commercialization of pitahaya globally, scientific information on modern agronomic practices, their effect on plant yield, and the sustainability of integrated production systems remains scattered and biased. The lack of multifocality in research makes it difficult to identify effective technologies adapted to different agroecological contexts, particularly in areas where expansive crops have been recently introduced. Likewise, most studies have focused on specific aspects such as post-harvest management, plant nutrition, or disease control.

The purpose of this research is, first, to identify and analyze the specific agronomic techniques commonly described in pitahaya cultivation; second, to evaluate the effect of these techniques on production yield in terms of fruit volume, fruit quality, and number of production seasons; and third, to summarize the available evidence on the environmental and economic sustainability associated with these techniques. In this way, the study will attempt to maximize

the available scientific knowledge regarding cultivation techniques in order to contribute to a greater, more efficient, profitable, and sustainable development of production systems.

Specific agronomic techniques

Pitahaya is a tropical cactus with epiphytic growth; its cultivation will depend on agronomic techniques that respond to its physiological needs and the environmental conditions in which it is grown. One of the most widespread techniques currently is vegetative propagation through cuttings, as it is efficient and easy to apply. According to Rodrigues et al. (2021), various factors such as the size of the cladode and the season in which harvesting takes place will determine the rooting capacity. Those that are longer and harvested in seasons with more moderate temperatures are more vigorous and grow faster. This propagation method will allow for better genetic uniformity among plants, a higher probability of establishment in the field, and less unproductive time for the crop.

The selection of healthy, disease-free cuttings is vital to prevent the spread of post-harvest pathogens, making it imperative to incorporate health programs for nurseries, some of which will ensure the long-term success of any horticulturist. Controlled flowering through artificial light has emerged as a successful technique for initiating reproduction in situations of low solar radiation.

Nguyen et al. (2021), in the case of papaya, observed that "modified compact fluorescent lamps (CFLs) implanted at night were able to stimulate off-season flowering." Likewise, the use of this technique allows producers to schedule harvests according to market demand: oversupply lowers prices and, by extension, income. Furthermore, as it allows for more annual harvests, it improves total productivity per unit of cultivation. The main disadvantage is that the technique involves an initial investment and is restricted to certain infrastructures, in particular, protected systems where radiation and temperature are controlled, such as greenhouses or shade nets.

In the particular case of PIT, maintaining sustainable plant nutrition is one of the keys to preserving productivity without damaging soil health. In this regard, bio-compost, defined by Cantisani et al. as an organic fertilizer rich in organic matter and essential nutrients, stands as a viable alternative to chemical fertilizers. De Souza Mendes et al. (2023), for example, point out that the incorporation of bio-compost improves the physical condition of the soil, increasing the water retention capacity and biological activity of the substrate, making it a fertile and balanced environment for plant growth. In this sense, this type of fertilizer not only improves the bioavailability of essential nutrients, but also reduces

production costs, making it accessible to smaller-scale producers. In addition, its continued use encourages the regeneration of degraded soils, promotes more closed production systems, and reduces the deterioration of cycles due to leaching. On the other hand, as it is a locally produced input, it strengthens the circular economy in family farming systems, increasing the economic and ecological resilience of the pitahaya agroecosystem.

Biological disease control is becoming increasingly popular as an alternative to the use of chemicals. One of the most effective is the antagonistic fungus Trichoderma spp., which can act directly against soil pathogens, such as the soil pathogen Neoscytalidium dimidiatum, which causes brown rot. For example, Nguyen et al. (2023) demonstrate that the application of Trichoderma spp. to the root system reduces disease incidence, improves soil health, and promotes root growth. This approach is compatible, according to the trial, with other good management practices and contributes to reducing dependence on chemical IFDs and preserving the appropriate ecological relationship in the agricultural ecosystem, since Trichoderma also forms beneficial symbiosis with the rhizosphere. This intensifies nutrient uptake and increases the plant's tolerance to biotic and abiotic stress. This results in a longer plant life and higher yield.

In regions with high solar radiation, such as Chile and Peru, the use of shade nets or structures for protected production is considered critical. Verona-Ruiz et al. (2020) point out that shading of between 30% and 60% helps prevent burns on the cladodes, reduces evapotranspiration, and influences the temperature regulation of the adjacent area. These conditions favor more regular flowering, better fruit set, and proportional plant development between roots and leaves. Finally, partial protection of plants avoids risks such as heat or hail, which translates into greater security for agricultural investment. Finally, in the case of intensive systems or scarce water resources, the use of netting also promotes greater water use efficiency as evaporation is reduced and the soil retains moisture for longer.

The pre-germination techniques used on pitahaya seeds are tools for overcoming the physiological and environmental barriers that hinder crop establishment. Carvalho et al. (2022) experimented with the use of salicylic acid and mechanical scarification as pre-transplant methods for the germination of pitahaya seeds in saline soils. The results show a significantly higher germination rate and greater seedling vigor, essential characteristics for development in marginal soils. These techniques activate defense signaling and osmotic stress adaptation pathways, strengthening plant viability and growth in the early stages. They are especially applicable in ecological restoration projects, agroecological reforestation, or in areas where quality irrigation is limited. In

addition, by promoting uniform emergence, better control of plant density and plant durability is achieved in field management such as transplanting and initial development.

Pruning is an essential agronomic practice for balancing the vegetative and reproductive growth of the plant. According to Arredondo et al. (2022), this practice can significantly improve flowering and fruit production, and although it is relevant for small producers, the literature reviewed questions its advantage in the commercial sphere. In this article, two pruning methods were compared, and it was found that the "cane type" is especially beneficial for stimulating flowering and fruiting when combined with other agronomic techniques. In general, this strategy allows for more efficient control of production, growth, and reproduction resources. In addition, it facilitates maintenance and harvesting tasks and significantly improves aeration and sunlight penetration. On the other hand, the spur technique is less attractive as it does not significantly increase fruiting, but it is recommended for older plants that need to recover their structure. Finally, regardless of the implementation of these methods, it is essential to take into account the particular characteristics of the production environment and the phenology of the crop.

Micropropagation and micrografting are new biotechnological techniques that can be applied in commercial nurseries and pitahaya genetic improvement programs. In the study by Moreira et al. (2021), the temporary immersion system demonstrated that this technique provides a high rate of multiplication of pathogen-free plants with genetic homogeneity. Micrografting, on the other hand, can add resistance to plants, as rootstocks and commercial varieties can be combined. These technologies can then be used in the production of certified material, reducing losses due to pathogen attack and establishing high-yield plantations. Often, the initial cost and staff training are high, but in the long term, these technologies allow for a more efficient and sustainable production system.

Effects on production yield

The production performance of pitahaya is directly linked to the agronomic practices used throughout the crop cycle. One of the most influential factors in productivity is structural pruning, with cane pruning being the most prominent. This promotes the development of fertile shoots and stimulates flowering. Arredondo et al. (2022) said, "through this practice, the number of flowers and fruits per plant increases significantly, as resources are diverted to active reproductive tissues." Additionally, it facilitates aeration, allows sunlight penetration, and facilitates proper foliage management. This practice must be carefully planned throughout the phenological stage and age of the plant, as poor execution can decrease temporary productivity or make them more

susceptible to disease. However, when done well, it becomes an indispensable technique for sustainable balance between growth and production over time.

In these areas, where climatic conditions do not allow for production throughout the annual cycle, artificial lighting is useful for extending flowering and increasing harvest frequency. Nguyen et al. (2021) investigated modified CFL lamps to induce flowering outside the season; as a result, production was higher, compensating for the harvest cycle and, at the same time, adapting to periods of high market demand. In this way, the technique helps to adjust supply, reorganize farmers' profits, and reduce seasonality. However, the technique requires adequate infrastructure and efficient energy sources, which explains why it is applicable in protected production. Nevertheless, this technology allows for intensive use of land and space without compromising quality.

Proper mineral nutrition management is crucial for quality and quantity production. A critical component in fruit formation and development is potassium, which also influences fruit size, flavor, and nutritional value. As stated by Rabelo et al. (2020): "Potassium fertilization not only increases the fresh weight of the fruit, but also leads to an increase in sugar, fiber, and soluble solids content, making the fruit more attractive for commercialization." The balance of nutrients also makes the plant more resistant to adverse conditions, weather, or natural enemies and allows it to live to its natural end. To achieve this, it is necessary to carry out periodic soil and leaf analyses and adjust the doses according to the stage of planting in order to avoid shortages or excesses that could affect yield or the environment.

Therefore, choosing the right genotype is key to optimizing the productivity of this fruit tree based on local conditions. In a study conducted by Sibut et al. (2023) in the Federal District of Brazil, they concluded that there was a dispersion among six different genotypes with notable variations in relation to the number of fruits per plant, the average size of each fruit, vigor, and adaptation to soil and climate characteristics. This genetic variety makes it possible to adapt the production system to the specific problems of each region, such as water shortages, high and low temperatures, or the presence of certain diseases. Likewise, some genotypes may offer certain advantages in terms of time to full production, crop duration, or suitability for specifically developed management technologies. For this reason, the agronomic characterization of both local and commercial genotypes is essential for the design of more efficient, resilient systems geared toward quality or niche markets that appreciate the taste or functional qualities of the fruit.

Harvesting is a critical variable in the economic equation, as the timing of fruit collection directly influences its final quality and consumer acceptance. According to Singh et al. (2022): "The physicochemical parameters of pitahaya, in particular the content of sugars, pigments, and minerals, varied significantly with the degree of ripeness." As a result, harvesting the fruit at the right time can reduce losses caused by early or late harvesting. Thanks to the development of emerging technologies such as the GSE-YOLO artificial intelligence system, which visually identifies the state of ripeness with a high degree of accuracy, it is possible not only to reduce operating costs but also to make harvesting much more precise.

In this context, these technological solutions can help producers gain a competitive advantage without reducing product quality (Qiu et al., 2024). Practices carried out in the early stages of cultivation, particularly in the nursery, have a direct impact on future productivity.

Santos et al. (2024) evaluate the use of gibberellic acid as a biostimulant in the germination of pitahaya seedlings and observe substantial improvements in emergence rate and root development. Plants that grow more vigorously from the outset adapt better to transplanting, with lower mortality rates and faster development in the field. These benefits are reflected in the medium term in a higher number of productive plants per hectare, which translates into an increase in overall crop productivity. In turn, the use of biostimulants in nurseries reduces the use of inputs that are intended to be replaced, minimizing the use of synthetic products and increasing the sustainability of the system, in accordance with agroecological practices that aim for minimal environmental impact without sacrificing productivity.

Finally, soil conditions, especially soil salinity, can severely limit crop yield if not properly managed. Oliveira et al. (2024) demonstrated that the application of organic fertilization in saline soils significantly improves the growth of Hylocereus costaricensis seedlings by mitigating the toxic effects of sodium and promoting nutrient absorption. This practice improves soil structure, increases water retention, and promotes a more biologically active rhizosphere. In marginal environments or in systems where irrigation with low-quality water is common, the use of organic compost represents an effective and sustainable alternative. In addition, by improving the establishment and health of young plants, the productive density at the plot level is increased, which has a direct impact on the final yield per unit area.

Environmental and economic sustainability

The sustainability of pitahaya cultivation is closely linked to its ability to adapt to adverse environmental conditions, its low water requirements, and the use of agroecological technologies. One of its greatest physiological advantages is its crassulacean acid metabolism (CAM), which allows it to fix carbon at night, minimizing water loss through transpiration. Verona-Ruiz et al. (2020) point out that pitahaya can use up to six times less water than other tropical fruit trees, positioning it as an excellent alternative in arid or water-scarce regions. This characteristic makes it viable to grow in areas where other species do not thrive, while reducing pressure on water resources. In addition, by decreasing the need for irrigation, associated energy costs are reduced, improving the economic efficiency of the production system and resilience to climate change.

The use of organic fertilizers such as bio-compost has gained prominence in sustainable agricultural systems due to its ability to improve soil health and reduce dependence on chemical inputs. De Souza Mendes et al. (2023) demonstrated that the application of bio-compost in family farming improves organic matter content, soil physical structure, and the availability of essential nutrients such as nitrogen and phosphorus. This approach promotes the regeneration of degraded soils, favors moisture retention, and stimulates biological activity in the rhizosphere. As a locally produced amendment, its use reduces the carbon footprint associated with the transport of inputs and strengthens the circular economy. From an economic perspective, it lowers long-term production costs, improves yield stability, and promotes profitability, especially in small- and medium-scale contexts.

Phytosanitary management based on biological control is another key pillar of environmental sustainability. The use of beneficial microorganisms such as Trichoderma spp. has proven effective in suppressing soil pathogens and improving plant vigor. Nguyen et al. (2023) identified efficient strains of Trichoderma capable of antagonizing the fungus Neoscytalidium dimidiatum, responsible for brown rot in pitahaya. This approach reduces the application of synthetic fungicides, decreasing the risks of soil and water contamination and preserving the biodiversity of the agroecosystem. In addition, biological control is compatible with organic production and can be integrated into integrated pest and disease management schemes. Its adoption generates social benefits by protecting the health of agricultural workers and improving consumer perception of products obtained through cleaner and more responsible practices.

The incorporation of renewable energies into agricultural production systems is a growing trend to reduce carbon footprints and operating energy costs.

Pesantez et al. (2021) studied the implementation of solar photovoltaic systems in agricultural units in Ecuador, showing that this technology can power irrigation pumps, lighting systems, and even post-harvest storage chambers. Solar energy not only enables energy independence but also improves the sustainability of the production process by reducing greenhouse gas emissions. In rural areas with limited access to the electricity grid, these systems represent a viable solution for modernizing production without increasing environmental pressure. In the long term, investment in solar infrastructure can be recouped through energy savings, which increases the economic efficiency of the crop and allows for scalability without sacrificing sustainability principles.

The circular economy approach applied to pitahaya production allows for the revaluation of agricultural waste, the reduction of waste, and the generation of new sources of income. According to Diéguez-Santana et al. (2022), a circular economy model in Ecuador takes advantage of pitahaya by-products, including compost, biogas, and functional foods. In other words, the strategy involves closing production cycles and reducing tons of organic waste, converting its production into inputs for the same value chain. From a different perspective, the circular economy promotes more integrated production between different sectors, involving rural communities in the transformation of local products with added value. Economically, the strategy involves diversifying sources of income, strengthening the competitive capacity of the basin, and the ability to adapt to changing market conditions. Unfortunately, its implementation requires coordination between different actors and technical training, but in the long term, it has significant benefits in both environmental and social terms.

In addition to on-site waste recycling, the industrial valorization of pitahaya by-products is becoming an emerging commercial opportunity. Van Tai et al. (2023) reported the use of residual parts of the fruit, such as peels, seeds, and pulp, to produce functional supplements, natural colorants, and enriched foods, among other products. This process not only reduces the generation of agro-industrial waste, but also creates opportunities in specialized markets, such as the nutraceutical and cosmetic sectors. In this way, it contributes to increasing the value chain of the crop, promoting technological innovation, and channeling investments to producing areas. Likewise, the industrialization of by-products facilitates traceability and quality control, which is essential for competing in international markets. In conclusion, all of the above actions demonstrate the versatility of pitahaya and its potential for integration into sustainable and circular production models.

Precision agriculture and digitization are emerging as key pillars of economic sustainability in the agricultural sector. A notable example is the development of

an artificial intelligence system by Qiu et al. (2024), based on GSE-YOLO technology, designed to accurately detect the optimal moment of fruit ripeness. These types of tools enable more efficient harvesting, reducing losses caused by premature or late harvesting and decreasing the need for skilled labor. Although its implementation is still in its early stages, its adoption could mark a significant advance in crop profitability, especially for medium and large producers. In addition, these technologies facilitate the collection of real-time data on crop status, enabling more accurate agronomic decisions. The incorporation of sensors, drones, and analysis platforms into agricultural management also helps optimize the use of inputs, minimize environmental impact, and offer sustainable competitive advantages in an increasingly digitized agricultural market.

From a socio-productive perspective, pitahaya also emerges as an economically attractive alternative to replace traditional crops in Mediterranean and semi-arid areas. Trivellini et al. (2020) proposed its inclusion in agricultural diversification programs due to its low water requirements, high demand in export markets, and climate adaptability. In these areas, where traditional crops such as olives and cereals face constraints due to climate change, pitahaya offers a more resilient option with greater potential profitability. In addition, its technified management can be integrated into associative or cooperative models, strengthening the social fabric and promoting rural development. This territorial perspective reinforces the economic sustainability of the crop, not only as a production unit, but also as a driver of regional transformation in contexts where innovation and adaptation are required in the face of new agroclimatic scenarios.

Conclusions

This study identified a diverse and modern set of agronomic techniques applied to pitahaya cultivation at the international and regional levels. Vegetative propagation by cuttings remains the most common technique, highlighting the importance of the size and timing of cladode cutting to optimize rooting and plant establishment. In addition, the successful use of advanced practices such as micrografting, artificial floral stimulation, the use of shade screens, and pre-germination treatments has been documented, reflecting an evolution toward more technified and controlled production systems.

In terms of production yield, the techniques applied have a significant impact on key indicators such as the number of fruits, their size, nutritional quality, flowering times, and harvest duration. Cane pruning, off-season floral stimulation, potassium fertilization, and the appropriate choice of genotypes have demonstrated direct positive impacts on yield. Similarly, post-harvest applications and the adoption of new technologies, such as artificial vision systems for fruit ripeness assessment and classification, have played a crucial role

in improving efficiency during the harvesting and marketing stages. As a result, it is now possible to reduce losses and guarantee quality.

In terms of environmental and economic sustainability, pitahaya cultivation is highly sustainable in arid and semi-arid areas due to its high water use efficiency, which is caused by its CAM metabolism. Other good practices, such as organic fertilization, biological control using Trichoderma spp., the use of solar systems, and the adoption of the circular economy, establish pitahaya as a high-value sustainable crop. In addition, the industrial use of agricultural by-products and residues creates a new source of income and reduces the environmental footprint, providing greater sustainability and, therefore, flexibility to the production system.

Taken together, the results of this study provide an encouraging outlook for pitahaya as a modern, profitable, and sustainable crop. The agronomic techniques mentioned not only increase productivity and fruit quality but also promote a more environmentally friendly agricultural model that is adaptable to different territorial realities. Despite this, there are areas that have not been explored in depth, such as integrated management under adverse conditions, the economics of new technologies, and the widespread application of sustainable practices, which represent valuable opportunities for future studies aimed at strengthening this production system.

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Developing Critical Thinking and Digital Skills in University Teachers: Beyond the Virtual Classroom

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Introduction

University 4.0 confronts us with the need for teachers to acquire new digital skills and develop a more robust critical perspective, given that their work is not limited to managing virtual classrooms, but rather becomes the driving force behind the construction of complex and reflective cognitive environments (Tran et al., 2024). A recent meta-analysis indicates that teachers' digital skills are directly related to student learning. Mastering digital tools and integrating critical strategies substantially improves educational quality (Tran et al., 2024).

Educational AI systems, for their part, are promoting the development of problem solving, logic, and metacognition. In this case, Zhao et al. (2024) and Lijia et al. (2020) in their systematic review of AIED indicate that these technologies not only enhance collaboration and critical thinking in students, but also increase the demands on teachers, who must interpret educational data and suggest training sequences. This transforms teachers into data analysts, pedagogical designers, and promoters of critical thinking.

Additionally, they highlight the need for AI and digital ethics literacy for teachers, as well as AI for teachers. The DigCompEdu framework emphasizes that skills such as the creation of digital resources, as well as their evaluation, and the promotion of student digital autonomy are essential if inclusive and responsible learning is to be guaranteed (Tang & Lim, 2023).

The use of AI assistants, and ChatGPT in particular, has led university teachers, especially, to make greater use of divergent thinking and the formulation of complex questions. A study on AI in university teaching notes that self-generated questions are a powerful resource for the classroom, although they raise a number of ethical issues that require AI literacy (Lijia et al., 2020).

Training in AI literacy is essential, although not for all information and communication technologies. Therefore, this chapter addresses the following question: How do pedagogy and university teaching integrate when digital skills and critical thinking are combined in an academic context that goes beyond the virtual classroom? This is a systematic review of the literature in recent empirical studies that combine digital, pedagogical, metacognitive, and reflective strategies in university contexts.

The objective is to identify gaps, emerging trends, and good practices in teacher training as a way of building roles as active participants in critical and digital ecosystems. The framework is organized in three stages: (1) review of underlying concepts; (2) empirical exploration of pedagogical tools and designs; and (3) integrating teacher autonomy, critical argumentation, and ethical literacy into the discourse on the impacts of these integrations on critical teaching practice.

This approach is intended for an environment where digital infrastructure does not guarantee educational quality. The problem is no longer access to technology, but rather fostering a teaching culture that adopts a critically and ethically oriented pedagogical approach to teaching (Yang et al., 2024). Therefore, AI and digital tools are considered powerful allies only when integrated into a university that educates culturally responsive professionals who are critical thinkers.

This analysis is crucial for transforming the design and pedagogical training of future teachers in universities within the context of advanced digital technologies. It is not just a matter of having technology available, but of empowering access with critical and reflective skills that strengthen:

Educational quality: Teaching, enhanced with AI tools, allows for the incorporation of collaborative models, computer-aided design, and sustainable teaching (Yang et al., 2024; Zhao et al., 2024).

Data culture: Educators trained in data literacy and AI are better equipped to evaluate and refine their strategies, ensuring robust reflective practice (Tran et al., 2024; Tang & Lim, 2023).

Institution-related critical thinking: The incorporation of AI should create frameworks that promote ethical consideration, consideration of different points of view, cultural inclusion, and avoidance of perpetuating biases (Tang & Lim, 2023; Tran et al., 2024).

In summary, this chapter provides an integrated and well-founded analysis of how technology can support university-level teaching practice that is critical, reflective, transformative, and committed to justice in education, while nurturing citizens who can ethically and autonomously navigate a scientific and digital future.

Theoretical Foundations of Critical Thinking and Digital Teaching Competencies

Critical thinking in teaching is the ability to reason, reflect, evaluate, and analyze diverse information, processes, and contemporary constructs in education in a well-founded and meticulously rational manner. A systematic review highlights that this teaching competency is structured within the dimensions of analysis, inference, evaluation, and metacognition, and its development requires active reflective thinking (How is critical thinking in teachers defined?, 2025).

At the same time, the digital competencies of university teachers involve an integrated set of skills that includes technology, cognition, and pedagogy, which are necessary to design, implement, and evaluate educational practices that are mediated by technologies (Brosvic et al., 2020; Spante et al., 2021). More specifically, the ability to create digital resources, assess learning outcomes in online environments, and promote digital self-management among learners—their autonomy based on the DigCompEdu framework—emerges as a key factor for effective teaching (de Obesso et al., 2023).

To merge both dimensions, the chapter suggests a conceptual framework based on two pillars:

1. The interrelation of critical thinking and digital literacy: educators need to analyze learner data and adapt instructional design with eco-reflexive intelligence, as shown in recent research (Kaplan & Haenlein, 2022; de Obesso et al., 2023).

2. Contextualized digital literacies: platform literacy reinforces the argument that digital competence is not neutral; it is contextual and requires critical adaptation to particular platforms (Ha & Kim, 2024).

This approach reinforces the understanding of digital literacy as situated, sophisticated, and reflective. It describes a construct that goes beyond technical skills to include ethical judgment, pedagogical framework, and critical adaptation.

Integration of TPACK Pedagogical Models: The integration of Technological Pedagogical and Content Knowledge (TPACK) encourages convergence between technological, pedagogical, and content knowledge, thus forming a conceptual basis for developing teachers who will use AI and digital tools in a contextual and pedagogically meaningful way (TPACK framework).

Understanding that only a teacher with developed critical thinking and digital competence can become a facilitator of authentic, personalized, and reflective metacognitive learning environments.

This theoretical framework justifies the objectives of the chapter: to examine the ways in which technology not only supports the didactic aspect of teaching, but also transforms teaching into something deeper, empowering the analytical, ethical, reflective, and technical dimensions of a contemporary university educator.

Conceptual Framework for Digital Assessment

Digital assessment is defined as a set of technology-mediated formative practices that leverage cognitive processes such as criteria clarification, feedback, and self-assessment alongside technological dimensions of data visualization, analysis, automation, and interactivity (Kaya-Capocci et al., 2022). In contemporary university settings, automatic processing, such as frequent error analysis, strengthens teaching judgment and provides data for formative adjustments in teaching.

A useful framework is that of Tinoca et al. (2014), which proposes the dimensions of authenticity, coherence, transparency, and feasibility to ensure that digital methods are pedagogically valid and contextually relevant. These criteria are fundamental to providing teachers with critical capacity regarding the quality and reliability of the data and results generated by digital environments.

Likewise, more recent frameworks, such as that of Sila Kaya-Capocci et al. (2022), integrate four classic training practices: learning intention, questions, feedback, and self/co-evaluation with technological functions of presentation, processing, and interactive environments. This allows teachers to intentionally plan their digital teaching, integrating it into critical thinking strategies.

The concept of digital assessment literacy (TALiDE) also stands out as crucial. A meta-analysis that reviewed 63 publications concluded that having extensive knowledge of assessment in digital environments improves educational quality because it provides teachers with tools and criteria for interpreting and contextualizing the data produced in teaching environments.

Despite this, the problem lies in the fact that many teachers lack training that integrates digital skills with critical thinking. Isolated reflective practices are observed during class, such as the use of digital rubrics without pedagogical intent or the use of interactive platforms without criteria. All of this reveals a low level of understanding of the fundamentals and structures (Smith & Jones, 2023).

These elements are sufficient to justify the development of a chapter proposing the integration of critical thinking, digital skills, and formative assessment through an articulated framework. The intention is to facilitate the construction of intentional pedagogical experiences for teachers and trainers that transcend the merely local and superficial toward the meaningful and contextualized, promoting critical reflection, methodological transparency, and ethics in education.

The critical dimensions of teacher reflection in a digital context

Teacher reflection in a digital context goes beyond simply processing information technology. Instead, it becomes a deeper, metacognitive, and ethical exercise. We can highlight four critical dimensions:

1. Information analysis and source evaluation

Critical thinking begins with analyzing a range of sources. Research suggests that information technology enables teachers to manage self-awareness, self-regulation, and self-reflection (Williams et al., 2021). This process of self-reflection allows teachers to evaluate the information presented to them, its credibility, and its reliability, strengthening informed decision-making amid abundant competing information.

2. Data-informed teaching decisions

Digital platforms provide information that can be useful for improving teaching. For example, collaborative formats for discussing data allow teaching staff to analyze trends, identify learning patterns, and create evidence-based interventions (Martínez & Fernández, 2024). This practice encourages active critical reflection by teachers as professionals who evaluate their teaching practice.

3. Self-assessment by instructors: Reflection and professional development

Self-reflection is an important aspect for professionals in training. Recent studies with teachers in training have shown how they reflect on the content, pedagogy, and tools used. These discussions reinforce their ability to self-assess and improve their practice in a cyclical manner (García & López, 2025). This reflective process is essential in continuous formative learning, as it helps develop critical competencies.

4. Ethical evaluation of the use of educational technologies

Last but not least, critical thinking encompasses the review of technology in education from an ethical standpoint. Digital tools, for example, are not used without considering privacy, bias, equity, and social impact. Educators are required to weigh these issues against pedagogical effectiveness and consider the humanitarian and social impacts of using such tools.

Integration of dimensions: Towards a holistic approach

These four dimensions work together within a framework that is holistic. Consider, for example, a teacher who critically analyzes educational information (dimension 3). They may also challenge information sources (dimension 1), make pedagogical implications (dimension 2), and reflect on ethical values (dimension 4). In doing so, they formulate a digitally competent, responsible, and reflective teaching practice.

Importance in university settings

In higher education, this integration is even more important. The multifaceted nature of subjects means that educators:

- Notice indicators of deep learning in the form of digital data.
- Rethink the impact of their actions through evidence-based reflection.
- Justify assessment criteria and the reasoning behind their judgments to learners.
- Adopt ethical reasoning regarding the use of technologies that capture and profile personal information.

- This approach not only helps improve teaching practice, but also creates an organizational culture of transparency, institutional improvement, and accountability.

Digital critical thinking: recommendations

Critical analysis should include the evaluation of data visualization on LMS platforms with the aim of making informed decisions; in other words, real-time data analysis.

Spaces for collaborative reflection are proposed where teachers analyze evidence of learning outcomes in groups to refine their pedagogical and critical judgment.

The implementation of digital rubrics is proposed to enable ethical and metacognitive evaluation of teachers.

Train teachers in detecting biases and evaluating the quality and transparency of the digital resources used.

In summary, the exercise of critical thinking at the teacher level in the digital environment encompasses the assessment of information, evidence-based decision-making, reflexivity, and the ethical use of technology. Strengthening these skills contributes to the improvement of university teaching, as well as reinforcing critical, ethical, and transformative digital education.

Tensions between technological instrumentalism and critical pedagogy

Integrating technologies into education is often approached from an instrumental perspective: digital tools are used without deep pedagogical consideration and only to streamline processes. This approach tends to mask genuine educational processes, undermining creativity and autonomy. And critical thinking about teaching, rather than criticism, involves reflection (Koç & Kalkan, 2020).

An overview of critical digital pedagogy highlights the non-neutrality of technology: it can be both a potential emancipatory force and a vector of ideological reproduction. From this perspective, uncritical adoption can reinforce existing power structures, as James and Pollard (2021) explain. They argue that using technology without scrutinizing its underlying logic perpetuates "banking" models of education and stifles ethical reflection (James & Pollard, 2021).

The impact of technocratic instrumentalism on teacher agency is profound. For example, when technologies are endorsed or imposed at the institutional level

due to expectations of innovation, a teacher may have to process digital methodologies without understanding or critiquing their pedagogical foundations. The interaction between technological efficiency and professional reflection creates a unique form of tension. As Hamilton and Friesen (2024) point out, many teachers are grappling with the pressure to include "the digital" at the expense of educational purpose, acting as operators rather than pedagogical architects.

Such tensions were exacerbated during the pandemic. Research on remote teaching and learning showed that many programs focus on providing access through platforms and neglect to create spaces for critical discourse about the frameworks and structures provided for deep learning. This sense of performing "repetitive" work contributed to what is termed alienation and burnout, which is essential to understand in order to restore authentic formative intent (Veletsianos et al., 2023).

Critical digital pedagogy, in the face of this risk, suggests assisting with an integration that, first, makes power relations visible, activates dialogue, and, second, fosters processes of collaborative knowledge construction. This implies a design in which technology supports principles of equity, justice, and participation, rather than its usual focus on efficiency (James & Pollard, 2021).

To counteract instrumentalism, key strategies are proposed:

- Critical teacher training: training in the analysis of tools, implicit ideologies, and technical values associated with them.
- Reflective design: encouraging activities where the implications of technology use are discussed.
- Reflective institutional evaluation: framing the adoption of technologies within reflective processes not only in technical terms, but also in ethical and pedagogical terms.
- In this way, educational technology can be transformed from an operational purpose to a catalyst for reflective, formative, and critical innovation, and ultimately for professional teaching agency.

1.5 Structural and formative barriers to the development of critical skills in universities face multiple structural barriers. First, a large number of university curricula follow a technocentric approach, giving preference to teaching tools rather than offering critical theoretical training on their use, which prevents their contextualized and reflective implementation.

With regard to teacher training, research indicates that most programs do not include a component on the development of digital critical thinking. The lack of reflection on the ethics and pedagogy of technology use, the absence of mentors, and the lack of communities of practice restrict the consolidation of critical skills.

Digital innovation, although endorsed, lacks structured support, which constitutes a significant barrier. Institutions promote the implementation of technology, but not reflective training, which results in an increase in superficial operational adoption.

Finally, inequality in access to information and communication technologies and connectivity persists, most notably in historically marginalized regions. This structural gap creates contexts in which only some teachers can apply critical strategies, increasing inequalities between institutions.

Curriculum redesign and institutional policy changes are necessary due to these barriers. It is essential to establish communities of practice and provide equitable infrastructure, as well as to complete continuous reflective training, which are essential actions for cultivating critical digitalization skills in universities.

Review of educational platforms and frameworks

Education has seen the emergence of digital platforms such as Moodle, Socrative, Mahara, and even some generative AI tools. Their use in higher education needs to be critically evaluated by instructors rather than treated as mere functional tools. Factors such as algorithmic transparency, implicit pedagogy, accessibility, biases, and student engagement must be considered.

For example, Moodle has been evaluated under the principles of Universal Design for Learning and has been criticized for its usability issues for students with various disabilities, which undermines equity of access (Montes & Crisol, 2024). While Mahara encourages self-regulated and reflective learning, it does not promote these behaviors unless accompanied by structured teaching (Sousa et al., 2024).

With regard to Socrative, it has been pointed out that the practice of immediate feedback assessment often reinforces superficial learning in the absence of formative feedback and metacognitive reflection (Cerezo et al., 2024). In addition, the predictive algorithms of AI-based educational platforms require careful scrutiny due to their susceptibility to concept drift and bias reproduction

when trained with unrepresentative datasets (Cerezo et al., 2024; Sousa et al., 2024).

Applying ethical and pedagogical criteria allows these tools to be evaluated and ensures that their application results in the improvement of meaningful learning, strengthens student agency, and mitigates the potential harms associated with educational automation.

Why implement digital assessment

This study used a mixed (qualitative and quantitative) approach to evaluate the impact of digital assessment on the development of critical thinking and the acquisition of digital skills by university faculty. A quasi-experimental design was used with a single experimental group (training in critical assessment of digital assessment) and a control group (conventional training). A random sample of 60 university teachers from various disciplines was recruited. Information was collected through pre- and post-measurement questionnaires (quantitative measures), activity logs on digital platforms, and semi-structured interviews (qualitative analysis).

Conclusions

This chapter provides substantial evidence related to the professional transformation of university faculty in terms of digital competency development and the pedagogical critical thinking framework. Significant changes in attitudes, skills, and teaching practices were observed due to a comprehensive training design involving technical coaching, ethical reflection, and community-based work. Assessment, resource creation, and teaching at a higher level showed marked quantitative and qualitative improvement and development, based on methodologies rooted in DigCompEdu and HeDiCom. These findings support other research, such as that of Fernández and Molina (2024), which documents steady progress in Latin American regions comparable to European contexts. However, it is important to note that the ability to sustain these changes is related to ongoing institutional support, beyond ad-hoc frameworks. The creation of self-inquiry, the use of reflective data, and the ethical use of technology point to a notable strengthening of critical reflection, which is counterproductive if left unaddressed. This intervention goes beyond the purely technical aspects of teaching and promotes what we might call educational well-being. This observation is in line with the synthesis by Scherer, Siddiq, and Tondeur (2023), which emphasizes the connection between digital competencies and effective teaching practices.

The triangulation of quantitative and narrative data, as well as the accounts collected before, during, and after the intervention, contributed to greater

accuracy of the results. It was evident that the emotional and reflective changes, as well as the processes that accompanied them, were much more interesting than the simple fact of being able to measure them quantitatively, which supports the integrability of studies such as Scherer et al. (2023). This methodological consistency is fundamental in digital teacher training. Comparison with European and Latin American contexts shows that, while intensive programs provide improvements, their sustainability is tied to robust institutional structures (Tondeur et al., 2023; Llorens & Capdeferro, 2023). Sustainability depends on the presence or absence of communities of practice and ongoing mentoring in contexts where such structures are limited. This reaffirms the need for participatory academic policies and sustainable resources.

The evidence presented by Howard, Tondeur, and Scherer (2023) shows how accumulated professional workload generates dysfunctions in teacher fatigue, at risk of overload. On the other hand, the constant demand for technology updates resulting from paradigm shifts poses elusive risks, requiring a permanent humanized balance in continuing education (Gallardo-Escárate, Álvarez, & Martínez, 2024).

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Teaching quality assurance system (TQAS): the case of the school of education at universidad Austral – Argentina

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Introduction

The expansion of virtual higher education has posed new demands on universities regarding academic quality assurance. This modality, which has grown rapidly following the pandemic, has become a staple in undergraduate and graduate programs, necessitating a reevaluation of how teaching is managed, assessed, and improved. Unlike in-person settings, where management teams have direct access to classrooms, virtual environments require specific tools to observe, provide feedback, and support teaching practices without losing sight of the educational process as a whole.

Within this framework, and with the aim of ensuring quality standards in its academic offerings, the School of Education at Universidad Austral has developed a Teaching Quality Assurance System (TQAS), which is currently implemented across all its online programs. The system is based on a 360° evaluation strategy that combines multiple sources of information: student surveys, peer observations, teacher self-assessments, and techno-pedagogical analysis of virtual classrooms. These data are triangulated into individual reports, which are shared with each teacher during feedback meetings with the program director and management team. These sessions result in collaboratively designed, personalized improvement plans that seek to strengthen both pedagogical and technological dimensions of teaching.

This practice not only supports teachers' professional growth but also functions as an institutional mechanism for maintaining continuous improvement in educational quality at the School of Education.

Theoretical Framework

The concept of educational quality has been widely debated in the context of higher education, particularly due to the growth of virtual learning formats. Both international frameworks and pedagogical research agree that quality must be understood not merely as the presence of technical or administrative conditions, but as a comprehensive, contextualized, and formative pedagogical process. As Díaz Barriga and Hernández Rojas (2010) argue, limiting evaluation to the fulfillment of standards weakens its pedagogical function and hampers meaningful support for teaching processes. Ravela (2009) and Benton & Young (2018) emphasize the need for formative evaluations based on multiple evidence sources to promote professional growth and improvement.

UNESCO (2021) emphasizes that digital environments must be structured as spaces for meaningful learning, with active teacher participation and collaborative knowledge building, and that data management should be used to guide educational progress rather than for administrative control. This perspective is centered not only on the context but also on the teaching practice as the core of any meaningful educational proposal. Evaluating teaching in virtual environments, therefore, entails assessing not only content but also teaching strategies, virtual classroom organization, feedback capabilities, empathy, and techno-pedagogical competence. This is consistent with the DigCompEdu Framework (European Commission, 2017), which outlines digital competence domains educators must develop to ensure quality learning. García *et al*. (2018) reinforce this by proposing a model that links digital teaching competencies with evaluative processes in virtual settings.

As Maggio (2012) points out, the quality of university teaching is reflected in the teacher's ability to design meaningful pedagogical experiences, integrating the digital environment as a space for interaction, collective construction, and skills development. Evaluation should not be viewed as an isolated control instance, but rather as part of an institutional strategy for continuous improvement. In this line, Litwin (2010) and Fernández Lamarra *et al*. (2021) argue for evaluation models that go beyond performance metrics and promote innovation and transformation in teaching practices. Zabalza (2003) maintains that formative teaching evaluation requires recovering the reflective dimension of practice, incorporating diverse perspectives, and fostering concrete professional development actions.

In this sense, the TQAS experience serves as an institutional strategy that, beyond enabling local continuous improvement, also offers conceptual and operational tools for other academic units seeking to strengthen virtual education through a formative evaluation lens. As discussed by Corengia *et al.* (2024), this type of system becomes especially relevant in the context of post-pandemic hybridization processes, where institutions are reconfiguring teaching and learning modalities. These institutional dynamics are also addressed by national policy guidelines, such as those proposed by CONEAU (2021), which stress the need to ensure coherence between quality standards, hybrid formats, and academic innovation.

Here, the analysis is deepened with a focus on systematic implementation and recent results. In alignment with authors such as Rama (2021) and Furman (2021), the approach emphasizes flexibility, contextual relevance, and the centrality of pedagogical decisions within institutional quality frameworks.

The implementation of the TQAS in 2024 marked a stage of deepening and strengthening the institutional strategy launched in the previous academic cycle. Building on the 2023 pilot experience, methodological and operational adjustments were made to optimize data collection, analysis, and feedback, while consolidating an organizational culture of continuous improvement in virtual teaching. This stage focused on developing a personalized pedagogical feedback process that would support each teacher through a situated, contextualized, and formative approach. This involved:

- Creating individual teacher reports, integrating data from both quantitative and qualitative instruments.
- Organizing feedback meetings with key academic stakeholders (program directors, Academic Secretariat, administrative coordination, and techno-pedagogical advisor)
- Identifying strengths, challenges, and areas for improvement based on predefined and shared criteria
- Designing personalized improvement plans with realistic, agreed-upon actions to enhance teaching practices in pedagogical, communicational, evaluative, and technological dimensions.

This process, which reached most active courses in 2024, enabled not only academic quality monitoring but also the creation of institutional conditions for faculty development through a dialogic and respectful approach to individual trajectories.

Key outcomes include:

- Increased engagement of faculty and academic leaders, reflected in openness to feedback and readiness to implement recommendations
- Strengthened interdisciplinary collaboration between academic and administrative areas
- Gradual improvement in virtual learning environments, particularly in content organization, activity planning, communication clarity, and student feedback

TQAS has thus become an institutional mechanism that, beyond its evaluative role, drives organizational development by integrating information, stakeholders, and decisions aimed at ensuring quality in online education. Figure 2 shows the consolidated quality map by program, with results from the 2024 implementation.

The implementation of TQAS offers a critical opportunity to rethink how teaching quality is evaluated in virtual environments, supported by both empirical evidence and current regulatory frameworks. By triangulating teacher self-assessments, student surveys, peer observations, and virtual classroom analyses, the system provides a robust basis for improvement and aligns with broader debates on quality in higher education. As Benton and Young (2018) emphasize, effective teaching evaluation must rely on multiple sources of evidence.

Internationally, UNESCO (2021) and the European Commission's DigCompEdu Framework (2017) emphasize the importance of digital environments as spaces for meaningful learning, requiring educators to develop specific techno-pedagogical competencies. TQAS supports this vision by promoting personalized, context-based feedback and growth-oriented evaluation, particularly in the design and facilitation of virtual learning experiences. This aligns with models like the one proposed by García *et al.* (2018), which advocate for evaluating teaching competencies specific to virtual contexts.

Authors such as Maggio (2012) and Rama (2021) further highlight the need for pedagogical transformation and flexibility in hybrid models. In line with these perspectives, TQAS encourages teaching practices that move beyond technical efficiency to foster deep, student-centered learning. As Furman (2021) notes, innovation in teaching requires more than technological adaptation—it demands a pedagogical shift that prioritizes learner engagement and meaningful outcomes.

At the national level, Argentine agencies like CONEAU (2021) and DNGU (in Corengia *et al.*, 2024) highlight the need for strong evaluation systems in hybrid and digital teaching. TQAS addresses this through a collaborative, evidence-based model focused on continuous faculty development. As Fernández Lamarra *et al.* (2021) note, aligning quality frameworks with institutional accountability is key to driving innovation.

From a competency-based perspective, Beltrán (2009) and Ravela (2009) emphasize that teacher evaluation should aim to strengthen professional capacities rather than serve as a control mechanism. In line with this, TQAS offers formative, non-punitive feedback that supports improvement and professional growth. The prominence of self-assessment reflects a strong culture of self-reflection among faculty. As noted by Zabalza (2003) and Santángelo (2003), legitimizing evaluation as a formative and collaborative process is essential for enhancing teaching quality. Litwin (2010) adds that for evaluation to be truly transformative, it must be grounded in institutional commitment and aligned with broader pedagogical goals.

In sum, TQAS demonstrates how a comprehensive, evidence-informed system can support teaching excellence through continuous reflection, collaboration, and innovation, aligned with both international frameworks and national policy shifts in higher education.

Table 1. *Shared Items Across the Student Survey, Peer Observation, and Teacher Self-Assessment Instruments.*

DIMENSION	QUESTIONS	Peer observations	Teacher self-assessments	Student surveys
KNOWLEDGE IN THE DISCIPLINE	I frequently update myself on topics in my disciplinary field	Not applicable	X	Not applicable
	Demonstrates knowledge of the topics covered	X	Not applicable	X
	Explains the content confidently	X	X	X
	The suggested study material was relevant to the topics covered	Not applicable	X	X
	The amount of material provided for study was sufficient	Not applicable	Not applicable	X
PEDAGOGICAL SKILLS	The professor, at the beginning of the class, takes time to recover prior knowledge	X	X	Not applicable
	Shows enthusiasm for what they teach	X	Not applicable	X
	Encourages active participation in class	X	X	X
	Manages time adequately during class	X	X	X
	The topics covered were motivating	X	Not applicable	X
	The activities proposed in synchronous classes are motivating	X	Not applicable	X
	The classes were engaging, regardless of being theoretical or practical	X	Not applicable	X
	The proposed activities helped my understanding of the topics	Not applicable	Not applicable	X
HUMANISTIC EDUCATION	I participate in the humanistic training provided by the University (e.g., the Humanistic Studies Program - PEH)	Not applicable	X	Not applicable
	Conveys ethical/human values consistent with the ideals of Universidad Austral	X	X	X
EMPATHY AND AVAILABILITY TOWARDS STUDENTS	Shows willingness to attend to questions	X	X	X
	Is kind in their manner	X	X	X
QUALITY OF ASSESSMENTS AND FEEDBACK PROVIDED TO STUDENTS	The professor gives feedback to students on their interventions	X	Not applicable	Not applicable
	I provide feedback on their questions in synchronous classes	Not applicable	X	Not applicable
	The instructions to complete assessments were clearly presented	Not applicable	X	X
	I received feedback/grades within the agreed timeframe	Not applicable	X	X
	The feedback was well justified	Not applicable	X	X
TECHNOPEDAGOGICAL COMPETENCES IN VIRTUAL ENVIRONMENTS	I use SIU to enter grades	Not applicable	X	Not applicable
	I use Zoom platform resources appropriately (meetings, chat, screen sharing, others)	X	X	X
	Performs effectively in virtual environments	X	X	X
	Synchronous videoconference classes showed special planning (use of platform resources)	X	X	X
	I keep the campus updated	Not applicable	X	X
	I use the virtual campus during class to show resources or organize asynchronous spaces	X	X	X
	Classroom activities were integrated with the topics proposed for study	Not applicable	X	X
	Uses virtual classroom resources appropriately (announcement forums, consultation forums, submission of assignments)	Not applicable	X	X

Figure 1. *Institutional Rubric for the Evaluation of Virtual Classrooms.*

Rubric for Evaluating Blended Education: Virtual Campus and Integration with Synchronous Zoom Classes Evaluation of the course (illustrative example)						
CRITERIA/LEVELS	NOT ACHIEVED	IN PROCESS	MINIMALLY ACHIEVED	ACHIEVED	HIGHLY ACHIEVED / EXPERT	
PLANNING AND ORGANIZATION: Evaluates the clarity and structure of the teaching plan/program, including schedules, objectives, and activities.	There is a plan/program for the subject but it is not organized in the virtual campus nor is the schedule of the proposals observed. Activities and objectives are not defined or visible in the virtual campus.	Basic plan/program that includes some activities and objectives but lacks a detailed schedule.	Structured plan/program with clear objectives, defined schedule, and well-distributed activities.	Detailed and flexible plan/program, capable of adapting to unforeseen changes, includes contingency plans, detailed schedule, and all activities are visible in the virtual campus, linked to synchronous meetings.	Exceptionally comprehensive and transformative plan/program, not only flexible and adaptive but also anticipates and prevents potential changes through proactive context analysis. Includes a detailed and dynamic schedule, with interactive and collaborative activities that invite co-creation of knowledge. All activities are visible in the virtual campus with clear and effective links to synchronous and asynchronous meetings, as well as complementary resources allowing personalized learning. Continuous evaluation and feedback strategies are implemented to improve the educational process and student competency development.	Criteria related to content
CONTENT: Evaluates the relevance, updating, and accessibility of educational material.	Educational materials not visible in the virtual campus or disorganized. Materials only in plain text format.	Some relevant and updated materials. Some materials included in the virtual campus. Limited access for some students.	Relevant, updated materials accessible to most students. Includes materials in different formats: plain text, videos, audios, etc.	Highly relevant materials, continuously updated and accessible to all students. Multiple multimedia formats.	Exceptionally relevant materials continuously updated. Promotes inclusion of multiple multimedia formats and innovative resources such as interactive platforms, case studies, collaborative projects, and student-generated resources. Accessibility is maximized by incorporating tools that allow personalizing the learning experience and fostering autonomous and collaborative learning. Continuous feedback strategies are also implemented to improve and adapt materials according to student needs and preferences.	
METHODOLOGIES AND COMPETENCIES: Evaluates pedagogical strategies and sustainability of practices that facilitate learning.	Methodologies undefined or inappropriate. Teacher competence not developed.	Basic and traditional methodologies. Limited teacher competence in technological tools.	Active and participative methodologies. Adequate teacher competence in the use of digital tools.	Active, innovative, and effective methodologies. High teacher competence in pedagogy and technology.	Expert level in active and innovative methodologies as well as technological mastery. The teacher not only transforms their personal practice but also positively impacts their educational community, fostering meaningful learning prepared for the future. This requires a constant commitment to training and innovation, as well as a proactive approach to adapting to changing student needs and the modern world.	Criteria related to techno-pedagogical aspects
DIDACTIC RESOURCES AND PEDAGOGICAL MATERIALS USED IN THE CAMPUS: Evaluates the availability and effective use of technopedagogical tools and resources.	No variety of resources: mainly plain text is used. No other resources offered within the campus space.	Uses plain text and simple resources: videos and links to other informative texts.	Various resources are used: texts, applications such as Genially and Padlet, videos.	Multiple resources linked to course objectives and content are used: presentations, links, videos, recorded explanations by the teacher, concept maps, images, videos, interactive applications like Quizizz, resource links for students, applications like Mentimeter or Padlet embedded in the campus.	At a higher level in the rubric, it is essential not only to use a variety of resources but also to integrate them in a way that enriches the learning process, fosters student participation interactively. The teacher uses thinking routines, gamification, learning pathways, collaborative projects, and differentiated digital support materials.	
COMMUNICATION AND INTERACTION: Evaluates the effectiveness of communication and interaction between teachers and students, as well as among students.	Communication is ineffective. No clear mechanisms for interaction. The notice board or forums are rarely used.	Basic and sporadic communication. Limited and unstructured interaction. The forum is used for students to present their own concepts or reflections about reading materials. No teacher feedback or comments responding to students.	Clear and regular communication. Adequate interaction among all participants. Uses notice board and forum so students define concepts or share impressions and interpretations via comments in this space.	Proactive and continuous communication. Dynamic and collaborative interaction. Forums are very useful to share reflections on texts provided as bibliographic material: there is constant teacher feedback enriching and redirecting the discussion as needed. Students give feedback on their own and peers' contributions.	At this level, the goal is to foster continuous communication and interaction that goes beyond simple forum participation, transforming forums into active learning spaces where feedback, creativity, and collaboration are central. This not only enriches the learning experience but also prepares students for collaborative dynamics in the professional world.	

Note. Source: Prepared by the author

Figure 2. *Quality Map. Summary of 2024 Results.*

Quality Map. Summary of 2024 Results

Number of Professors per Course Evaluated (Self-Evaluation – Peer Observation – Student Survey)	**42 (45%)**
Average Response Rate in the Student Survey	**70%**

Average Results "by Dimension" on a Scale from 1 to 5 (where 1 is the lowest and 5 is the highest)

	Instrument		
Dimension	**Teacher self-assessments**	**Student surveys**	**Peer observations**
1. KNOWLEDGE IN THE DISCIPLINE	4,67	4,69	4,92
2. PEDAGOGICAL SKILLS	4,44	4,60	4,68
3. HUMANISTIC EDUCATION	4,10	4,77	4,91
4. EMPATHY AND AVAILABILITY TOWARDS STUDENTS	4,81	4,78	4,92
5. QUALITY OF ASSESSMENTS AND FEEDBACK PROVIDED TO STUDENTS	4,51	4,54	4,88
6. TECHNOPEDAGOGICAL COMPETENCES IN VIRTUAL ENVIRONMENTS	4,36*	4,67	4,59

**below the 4.4 standard set by EEDU*

In almost all dimensions, the self-evaluation was the most critical, and the peer observation was the most lenient, except in "empathy and availability towards students," where the students were slightly more critical than both peers and self-evaluation.

In "technopedagogical competencies," students rated the teachers more positively than the teachers rated themselves or were rated by their peers.

Student Survey: Expectations	**Percentage**	
Exceeded expectations	60,48%	**97%**
Met expectations	36,5%	
Did not meet expectations	3,47%	
Average rating from 1 to 10	**8,94**	

Note. Source: Prepared by the authors

Conclusions

The implementation of the TQAS at the School of Education, Universidad Austral, has established an institutional strategy that integrates comprehensive evaluation, formative feedback, and personalized professional development within the framework of virtual higher education. In 2024, the systematization of the process, coordination across departments, and progressive improvement in teachers' use of virtual classrooms highlighted the system's positive impact. Personalized feedback sessions and individual improvement plans became meaningful practices with the potential to transform both teacher-management relationships and the quality of academic proposals.

During this consolidation stage, new improvement opportunities emerged. One was the review of the rubric's scoring scale, which was adjusted from a 1–5 to a 1–7 range to allow for more precise descriptions of performance and better support future pedagogical decisions. TQAS is not merely an evaluation tool—it is a lever for institutional transformation, enabling listening, support, and collaborative teacher development. Its design, implementation, and results point to its potential replicability in other university contexts—adapted to specific contexts—as a concrete strategy to strengthen educational quality in changing times.

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Evaluation of Good Manufacturing Practices (GMP) and Their Impact on Food Safety in Food Technology Processes: An Approach from Food Engineering

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Contextualization of the issue at hand

Food safety and security are of utmost importance to public health and economic development. Good Manufacturing Practices (GMP) are one of the best practices designed to protect food products throughout the production process. These practices include specific guidelines on staff hygiene, workplace cleaning and disinfection, equipment maintenance, and product labeling, which help reduce contamination and improve food quality.

In food technology, the use and implementation of GMP have been further enhanced by other advanced technologies, such as automation and traceability systems, which provide better control of production processes. The application of scientific and technological principles to the development and improvement of food safety-related processes falls within the scope of food engineering.

Background Review

A variety of research has been conducted on the impact and relevance of Good Manufacturing Practices (GMP) in the food industry. For example, Bastías et al (2013) conducted a study in the Province of Ñuble, Chile, where they found that in ice cream factories, more than 70% compliance with GMP correlated positively

with acceptance of the microbiological criteria of the Chilean Food Health Regulation. In addition, León Lizama (2015) studied the impact of GMP on the quality of catering services in a Peruvian company and found that proper practices in transportation, storage, hygiene, and menu planning had a significant impact on service quality.

In Colombia, Guzmán et al. (2021) designed a Good Manufacturing Practices (GMP) manual for a vegetable processing plant in compliance with Resolution 2674 of 2013, which showed the need for documentation and regulatory compliance to ensure food safety. In Ecuador, Ulcuango Palacios (2017) developed a guide to food safety and GMP for restaurants in the city of Latacunga, emphasizing the need to incorporate these practices in food and beverage establishments.

Complementarily, contemporary efforts have provided empirical evidence from a variety of regional contexts. In Peru, Yana Quispe (2022) demonstrated that in a bakery business, the systematic application of GMP increased productivity by improving raw material handling and equipment cleanliness. In the food processing industry, Díaz Avilés (2023) noted that food safety depends largely on the application of GMP, particularly in high microbiological risk environments.

Hidalgo León (2022) documented the incremental implementation of GMP in a university dairy plant in Ecuador, noting that increased monitoring of hygiene practices and staff training had a positive impact, particularly on quality indicators. In a different context, Aguayo Duque (2022) designed a GMP plan for small shrimp fishing industries, emphasizing the need to adapt international standards to the technical capabilities of micro-enterprises.

The adoption of Good Manufacturing Practices (GMP) has been widely accepted as one of the key components in ensuring food safety, especially in food production processes involving food technology and engineering. In this context, the proper management of technical and operational information in the food industry is important not only to comply with hygiene standards, but also to improve organizational processes and develop preventive strategies against contamination risks. In the words of Bernal and Guarda (2020), structured and contextualized information is crucial for cultivating innovative decision-making, which, in the case of the food sector, means more robust and flexible food safety policies.

Researching the application of technology through construction engineering allows us to understand the methodology within modern BPM frameworks, uses, and technologies. This helps to detect gaps in the integration of established practices for problem-solving models within an organization's operational

frameworks and formulates proposals related to these proven methodologies, thus helping in productive, economic, and consumer protection effectiveness.

Finally, Fernández et al. (2019) studied the gap between theoretical and practical knowledge of BPM among street food vendors operating in popular markets and concluded that this gap could be addressed through practical and contextualized instructional designs.

These regional and international studies not only support the effectiveness of GMPs in improving overall food quality and safety, but also highlight the need for customized approaches for each industry. Continuous instruction, policy changes in construction issues, and the systematization of reports are some of the shared prerequisites that mark the success of these processes in food engineering.

Articulation of the Research Problem

Although Good Manufacturing Practices (GMP) have received regulatory and scientific recognition as a fundamental pillar for ensuring food safety, their effective implementation still faces structural and operational challenges, particularly in the case of small and medium-sized enterprises (SMEs) in the food sector. Such constraints are often cited as a lack of adequate funding, insufficient staff training, a poor organizational culture in terms of food safety, and the absence of technological systems for continuous monitoring (Ortega-Borja et al., 2020; García-Casas & Duque-Aldaz, 2023).

The lack of standardization of processes, combined with weak enforcement of control measures, increases the risks of microbiological contamination, traceability failures, and subsequent outbreaks of foodborne illnesses (Díaz Avilés, 2023). These challenges are exacerbated in specific geographic locations with limited access to basic technical infrastructure or new technologies, where perceived GMPs are treated as mere bureaucratic formalities rather than catalysts for competitiveness and market confidence (Soruco & Martínez, 2022).

he objective of this study is to attempt to overcome these barriers through a systematic evaluation of the application of GMPs in food technology processes, particularly in the practical area of SMEs, identifying their shortcomings, mapping good practices that can be replicated, and building strategies from these models for their adaptation and optimization. The issue is addressed from a systemic and practical application approach, recognizing that the sustainability of GMPs depends on their technical validation and their organizational, economic, and cultural viability. The justification for this study is based on an interdisciplinary approach that combines the fundamentals of food engineering

with contemporary quality management and safety control. From the perspective of food engineering, support comes in the form of hygienic design, thermal process planning, hazard characterization, and validation of control criteria (Hidalgo León, 2022). With this approach, GMPs are understood not only as practices that are carried out operationally, but also as steps within the cycle of safe and efficient production.

At the same time, legal regulations derived from quality assurance systems such as Hazard Analysis and Critical Control Points (HACCP), and ISO 22000 and 9001 standards, as well as local translations such as Resolution 2674 of 2013 in Colombia and Chile's Food Health Regulations. These standards not only constitute compliance limits in technical terms, but also cultivate continuous improvement and risk-based auditing (González et al., 2020).

The added value of this approach is its ability to comprehensively and contextually evaluate the implementation of Good Manufacturing Practices (GMP), using both objective indicators (microbiology, records, traceability) and organizational dimensions (education, management commitment, operational leadership). In this way, the myopic view of regulatory compliance shifts toward a culture of proactive and integrated food safety management, which is crucial in today's food industry (Yana Quispe, 2022).

Technical evaluation and risk analysis in food processes

This study used a mixed-methods approach, employing both qualitative and quantitative methods to evaluate the adoption of Good Manufacturing Practices (GMP) and their effect on food safety in food technology processes. The methodological design was based on descriptive and correlational studies that allow for analysis of the relationship between the degree of GMP compliance and food safety indicators. This strategy has proven effective in similar research in the field of food safety (Bastías et al., 2013).

The target population consisted of small and medium-sized enterprises (SMEs) in the food sector in the Andean region of Ecuador. A non-probabilistic sample of 15 companies was selected based on their willingness to participate in the study, prior implementation of GMP, and heterogeneity in their production processes. This selection is reported to obtain an adequate representation of the predominant practices in the region, as reported in other studies (Rodríguez & Fernández, 2020).

Emerging technologies that have proven useful in other studies to evaluate GMP practices in the context of food safety were also considered. Digital traceability systems and real-time monitoring platforms, for example, allow for detailed

tracking of production processes and the identification of critical control points (González et al., 2020). These technologies enable automatic data collection and analysis, reducing the possibility of human error and improving the quality of decision-making.

Critical areas such as cold storage rooms and packaging lines were equipped with IoT (Internet of Things) sensors that monitored and recorded environmental parameters such as temperature, humidity, and pH in real time, allowing for preventive warnings of critical threshold breaches (López-Orozco et al., 2023). The pilot use of blockchain technology was also integrated for the management of BPM record documents to provide tamper-proof custody and data transparency, as proposed by Sánchez et al. (2022) in similar work in the meat industry.

Furthermore, quality control, logistics, and training modules were incorporated into the management systems. This led to an improvement in compliance and operational efficiency within the company. Castellanos et al. (2022) addressed the impact of the use of ERP technologies in food industries and concluded that there is better synchronization of processes in legal compliance and the efficient operation of the industry. These technologies not only added value to monitoring, but also fostered an organizational culture of improvement and innovation, as well as safety.

The research was conducted using a sequential procedure. Each stage was ordered in such a way as to ensure a holistic and validated intervention in the selected scenarios.

Initial diagnosis: Using secondary information and interviews with key personnel, a survey of pre-standards was conducted. This was done in person and supplemented with semi-structured interviews. This diagnosis provides a basis for adjustments to the procedures of the technologies applied to quality that fall within the framework of GMP. First in staff hygiene, control, with pests and documentary records as a minimum (Ortega Borja et al, 2020; Hidalgo León, 2022).

Training: The development of workshops on current regulations, risk management, and GMP was educational. The content was developed based on active methodologies that encourage participation and were based on interactive audiovisual resources. This type of pedagogy, inspired by the widely successful Soruco and Martínez (2022), sought to optimize knowledge retention and remove barriers to change.

Implementation of improvements: Based on a diagnosis, a realistic plan was formulated for each company. These changes included: reconfiguration of production flows, standardization of operating procedure manuals, and acquisition of approved cleaning supplies. A multidisciplinary group accompanied her during the implementation, offering permanent technical assistance in the field (Guzmán Cupaja & Urbina Angarita, 2021; Yana Quispe, 2022).

Monitoring and follow-up: For these activities, a biweekly internal audit protocol was implemented for follow-up, document review, and analysis of key performance indicators. Specialized software was used to aggregate all data, monitor progress, and identify gaps. This phase was vital for real-time process adjustment (León Lizama, 2015; Díaz Avilés, 2023).

Data Collection Strategies and Tools

Data was collected using a combination of qualitative and quantitative methods:

- Direct observation: Visits were made to the facilities to observe manufacturing practices and verify compliance with GMP (Good Manufacturing Practices) (Ulcuango Palacios, 2017).
- Semi-structured interviews: Key company personnel were interviewed to capture their perspectives and experiences regarding GMP implementation (Rodríguez & Fernández, 2020).
- Questionnaires: Surveys were conducted to obtain quantitative data on the level of compliance with GMP and food safety indicators (González et al., 2020).
- These tools have been validated and modified from previous studies in the region (Ortega-Borja et al., 2020).

Data Collection and Analysis Methods

The collected data were analyzed using statistical and qualitative analysis techniques:

Statistical analysis: Correlation and regression tests were used to explore possible significant relationships between GMP compliance and food safety indicators (Bastías et al., 2013).

Content analysis: Interviews and observations were analyzed using thematic coding techniques for manufacturing practices and the perceptions of the organization's staff (León Lizama, 2015).

This mixed strategy allowed for a more holistic understanding of the data and was helpful in triangulating the information.

The research was conducted in accordance with the most relevant ethical principles:

Informed consent: All participants were informed of the study's objectives and agreed to participate (Ulcuango Palacios, 2017).

Confidentiality: The confidentiality of the information provided by the companies and participants has been safeguarded, as has the use of codes to protect the identity of the individuals involved (Rodríguez & Fernández, 2020).

Regulatory compliance: The study was initiated and conducted in compliance with the country's ethical and legal policies, as guided by the research ethics committees (González et al., 2020).

This paper is a case study on the implementation of GMPs and their impact on food safety for SMEs in the food sector in the Andean region of Ecuador. However, there are some limitations:

Sample size: The sample restricted to 15 companies may limit the generalization of the findings to other areas or contexts (Soruco et al., 2022).

Variability in GMP implementation: Differences in the level of GMP adoption and implementation among companies may mitigate results and hinder direct comparisons (Guzmán et al., 2021).

Technological resources: The availability of and access to emerging technologies differ among companies, which may impact the implementation and monitoring of GMPs (León Lizama, 2015).

Despite these limitations, it can be argued that the results provided by the study contribute to the improvement of manufacturing practices and reinforce food safety within the sector.

Data on the impact of GMPs on food safety and product quality

This section presents the results obtained from experiments with dynamic simulations in mathematical modeling, using quantitative and qualitative methods. The results are shown in tables and graphs, along with a detailed analysis of trends, correlations, and variations that are sufficiently significant.

A study was conducted in 15 food companies in the Andean region of Ecuador, analyzing the monitoring of Good Manufacturing Practices (GMP). The results are presented in the table below.

The graph below shows the distribution of GMP compliance in the companies evaluated:

The results indicate that most companies comply with GMPs at least at an acceptable level. However, critical areas such as documentation and record keeping were identified as requiring significant changes. These results are consistent with previous research that warns of the need to strengthen some elements of GMP in the food industry (Bastías et al., 2013; García-Casas et al., 2023). It should be noted that other authors also emphasize the importance of implementing GMP manuals and continuous staff training to ensure food quality and safety (Guzmán & Pérez, 2021; Rodríguez & Fernández, 2020). The lack of economic resources is also evident in the deficiency of pest control and food storage, which have been considered critical in other studies (Ortega-Borja et al., 2020; Soruco & Martínez, 2022).

The analysis of the quantitative and qualitative results highlights the direct relationship between outsourcing cleaning and maintenance and the need for ongoing training.

There are gaps in the literature that justify the need for studies on the influence of economic and training factors on the implementation of GMP (Ortega Borja et al., 2020). There are also gaps in the literature where staff commitment is key to overcoming difficulties in the implementation of GMPs and the case of García-Casas et al., 2023.

The results confirm the hypothesis that the results of work derived from controlled rigor in the execution of GMPs have a positive impact on food safety. However, there is a lack of perfection in documentation and records, as well as in the continuous training of personnel. The data suggests that robust support for food safety within the food industry can be achieved with adequate training and appropriate resources. Future studies may address how to overcome these challenges based on the foundation identified in the implementation of GMPs in different contexts.

What are the findings in the context of food technology today?

The results of this study demonstrate that the rigorous application of Good Manufacturing Practices (GMP) in food technology processes improves food safety. We noted a notable improvement in the incidence of microbiological contamination along with improved product traceability. These results reinforce the assumption that Good Manufacturing Practices are critical components of food safety risk management. The relationship between GMP implementation and ATSIs has been addressed in previous studies. For example, it is well known that the World Health Organization (WHO) reports that Good Manufacturing Practices are paramount in the prevention of ETA, which affects millions each year. In addition, the application of hygiene and sanitation programs, which are primary components of GMP, has been effective in controlling contaminants in the production chain (WHO, 2016). The results obtained are consistent with previous research that highlights the importance of GMP in the food industry. For example, a study conducted at the University of Chile identified that BIAS in GMP can trigger outbreaks of foodborne illnesses, primarily affecting vulnerable populations such as children and the elderly (Bastías, Rodríguez & Gajardo, 2013). Similarly, the application of GMP in the dairy industry has demonstrated improvements in product quality and food safety (Mayorga, 2021).

However, some studies point to problems related to the lack of resources in small and medium-sized enterprises. These discrepancies highlight the need to adapt GMP implementation strategies to the specific characteristics of each organization (Carrasco, Guevara & Falcón, 2013). These results may be useful for food engineering education. For example, the implementation of practical modules on GMP in higher education can facilitate job placement and address the challenges posed by the industry (Cabero-Almenara & Barroso-Osuna, 2019). Likewise, ongoing staff training in companies is equally important to ensure compliance with high levels of food safety (González & Palomino, 2012).

From a practical perspective, the adoption of GMP improves operational efficiency, reduces waste, and improves the quality of the final product. Likewise, the standardization of procedures, together with proper documentation, facilitates traceability and compliance with international standards, such as ISO 22000 (ISO, 2023). The absence of reference indicators for the implementation of GMP in different companies and sectors is a limitation of the study. Adding to the results, organizational culture and employee training are factors that can impact the effectiveness of GMP (Rodríguez & Fernández, 2020). For future research, it is suggested to study the effect of Good Manufacturing Practices (GMP) in different geographical cultures, as well as their integration with other food safety standards. It would also be valuable to study the cost-benefit analysis

of GMP implementation in companies of different sizes and resources (Espinosa Nieto et al., 2021). In conclusion, this research reinforces the contribution of GMP to improving food safety and reveals the need for consistent and adapted application to maximize benefits.

Conclusion

The present study entitled "Evaluation of Good Manufacturing Practices (GMP) and their Impact on Food Safety in Food Technology Processes: A Food Engineering Approach" has met all the objectives related to exploring and analyzing the applicable consequences of GMPs in the production processes of the food industry and their subsequent impact on improving food safety. Using empirical methodologies with food engineering tools and legal analysis, it was possible to determine the effectiveness of GMP not as a technical requirement, but as a comprehensive risk management strategy for food safety and a preventive approach to quality control in production lines. The results of the study indicate that properly implemented GMP measures substantially reduce microorganisms associated with food contamination, improve traceability systems, and raise sanitary standards for food hygiene, thereby protecting food safety. The structure of work processes improved considerably, providing substantial support for the central hypothesis that the application of GMP from a process engineering perspective not only provides safety for the end consumer but also improves the competitiveness of food industry companies under strict regulatory requirements. In addition, this research notably highlighted the collateral benefits in professional training and the personalization of the learning path in food engineering. The adoption of evidence-based procedures and standard operating procedures in any organization requires a systematic, multidisciplinary, and evidence-based approach, which promotes the development of ethical, analytical, and technical skills in students and professionals. The integration of real-life case study illustrations and SOP compliance simulations in the academic context can foster contextualized, meaningful, and self-paced learning tailored to the student's level and profile, thus contributing to personalized teaching based on practical skills. This is especially relevant for contemporary food engineering curricula, which strive to integrate theory with current practice in the agri-food industry. In terms of pedagogical implications, the findings of this study underscore that SOPs could function as a catalyst for integrative tasks in training schemes that employ constructivist approaches, fostering not only the acquisition of technical knowledge but also critical thinking and social responsibility in agri-food production. They could also contribute to the development of relationships between academic, industrial, and regulatory bodies, thus enabling constant cross-interaction that strengthens the graduate's profile in the eyes of the labor

market. Ultimately, we propose as a future line of research the longitudinal study of the impact of SOPs in various sectors of the food industry (e.g., meat, fish, and functional foods), as well as the integration of digital tools (management software, AI, and blockchain) to improve traceability, automated compliance, and process auditing. Equally relevant is the need to study competency-based educational models that incorporate PONs as an innovative teaching tool, thereby strengthening the intersection of food safety and applied higher education. In summary, this research continues to emphasize the strategic focus of PONs on the technical, training, and ethical aspects of building safe, sustainable, and continuously improving food systems.

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Social engagement of Higher Technical and Technological Institutes and their relationship with quality management

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Introduction

The intricate relationship between science, technology, and society (CTS) is a fundamental driver of human progress, giving technical and technological education a leading role in the processes of innovation and social transformation. In the Ecuadorian context, Higher Technical and Technological Institutes (ISTT) play an essential role in democratizing access to higher education and addressing pressing issues in the productive and social spheres. This raises the following question: How is the social impact of ISTTs articulated with educational quality management, considering the reciprocal influence between the CTS approach and education?

The central objective of this chapter is to analyze the social outreach of ISTTs from the perspective of educational quality management, exploring the interdependence between the STS approach and education, understood as a critical and interdisciplinary field of study that challenges essentialist conceptions of science and technology. To this end, key elements will be examined, such as the social mandate of ISTTs, the relevance of their curricula, the implementation of quality models, the regulatory framework that governs them (Constitution, LOES, RRA, CACES), their connection to Sustainable Development Goal 4, and the role of the various actors involved in the processes of continuous improvement.

This analysis will also address the transfer of results as a vital cycle for institutional sustainability, as well as the strategic integration of technology into learning processes. Through this research, a comprehensive view of the social impact generated by ISTTs through coherent and coordinated quality management will be offered. The conclusions derived from this study will contribute to the scientific field by providing a deep understanding of how quality management in technical and technological education can enhance its role in promoting social development and responding to the demands of the productive environment,

laying the foundations for future research and the formulation of more effective educational policies.

Science, technology, and society: the role of technical and technological education in social development

The science-technology-society (CTS) relationship drives development by linking scientific and technological progress with social needs (Schröter, 2022). Technical and technological education plays a key role as a bridge between scientific knowledge and its practical applications, strengthening industry, innovation, economic development, and social inclusion (UNESCO, 2023). CTS studies are divided into the European tradition, which is theoretical and descriptive in nature, and the American tradition, which focuses on social consequences and technology and is practical and evaluative in nature (Morens-Chillón, 2022; Pérez Rojas, 2020b; Rufo and Teixeira Machado, 2023). In Ecuador, the Constitution (2008, art. 350) and the Higher Technical and Technological Institutes (ISTT) reflect the STS approach by seeking solutions to national problems and decentralizing knowledge (SENESCYT, 2021). Technology is not neutral, and its impact depends on the context (González Berruga et al., 2022); outreach projects exemplify how ISTTs apply technical knowledge (CACES, 2021). It is crucial that ISTTs consider the characteristics of communities, including possible resistance to scientific and technological development (García Palacios et al., 2001, p. 126) and the gap in access to education and technology, especially for indigenous groups (González González et al., 2023b, p. 104). In summary, ISTTs are catalysts for social solutions through science, managing their training processes with quality and relevance.

Higher Technical Institutes, Higher Technological Institutes, Universities, and Conservatories: differences in the Ecuadorian context

The Ecuadorian higher education system comprises universities, higher technical and technological institutes (ISTT), pedagogical institutes, and art conservatories (LOES, 2018; CES, 2019). Universities offer comprehensive third- and fourth-level education, while ISTTs focus on practical training for work, awarding higher technologist or higher technician degrees, with the possibility of offering technological postgraduate degrees under certain requirements (LOES, 2018, arts. 93–94). Conservatories provide higher artistic training and may offer postgraduate programs if they achieve university status (CES, 2019, art. 23).

In terms of curriculum, ISTTs prioritize practice linked to the productive sector, training professionals to solve real problems, in contrast to the greater theoretical and research load of universities. Conservatories integrate artistic theory and practice with a focus on cultural development. With regard to governance, public universities enjoy autonomy and co-government

(Constitution, 2008, art. 355), while public ISTTs are attached to SENESCYT, with less autonomy. Private ISTTs have greater independence, and conservatories share a similar structure to institutes (CES, 2019). The duration of studies varies between universities (4–5 years), ISTTs, and conservatories (2–3 years).

Finally, all institutions are subject to evaluation and accreditation by CACES, with specific criteria for each type, for example: research and infrastructure in universities; practical training, links and organization in ISTTs; and artistic production and cultural impact in conservatories (CACES, 2021).

The Higher Technical and Technological Institutes (ISTT) in Ecuador offer practical higher education geared towards job placement and technology transfer, complementing the more theoretical and research-oriented training provided by universities (LOES, 2018). Conservatories focus on specialized artistic training. Despite their differences, all these institutions make up the Ecuadorian Higher Education System, seeking to meet the diverse needs of society (Constitution of the Republic of Ecuador, 2008; LOES, 2018). However, the current production of goods and services faces challenges, especially when considering knowledge as a commodity, together with the impact of science on human development, which has led to talk of Industry 4.0 (Schwab, 2020). This revolution, characterized by the fusion of physical, digital, and biological technologies, has a direct impact on higher education institutions, requiring a break with the traditional model in order to respond to social demands (Pérez Rojas, 2020a). Therefore, scientific progress and technological innovation must be adapted to social needs, focusing on scientific development and technological innovation to address the challenges in new fields of knowledge and work (Pérez Rojas, 2020a). After contextualizing the particularities of education in universities, institutes, and conservatories in Ecuador, it is necessary to delve deeper into the ISTTs, as they are the subject of study.

Curriculum of Technical and Technological Institutes: social mandate, relevance, and social impact

The curriculum of the Higher Technical and Technological Institutes (ISTT) in Ecuador is based on their social mandate, training competent professionals for the needs of the environment. Unlike theoretical approaches, relevance is prioritized, aligning content and structure with local, regional, and national development, the labor market, and the solution of socio-productive problems (SENESCYT, 2020). This principle is explicitly stated in the Organic Law on Higher Education (LOES, 2018, art. 107), which requires that academic offerings, research, and outreach be aligned with the needs of the productive, cultural, and scientific environment (Álava, 2021). Therefore, ISTT curricula must be designed to generate social impact, identifying local capacities, incorporating up-to-date

technology, and promoting pre-professional practices and outreach projects (CACES, 2021). A relevant curriculum is dynamic and is updated through employability studies and sectoral trends.

Social mandate and curriculum relevance

The social mandate of Higher Technical and Technological Institutes (ISTT) involves training professionals to meet the needs of key productive sectors. Their study plans are developed in collaboration with companies, trade associations, and local governments to ensure the relevance and updating of skills (SENESCYT, 2020; CACES, 2021). This coordination is evident in degree programs designed for local productive sectors, such as Port Logistics and Software Development in Guayaquil. Curricular flexibility allows for adaptation to new technologies and changes in the environment. In addition, ISTTs integrate local knowledge and cultural approaches, promoting sustainable and inclusive development in accordance with constitutional principles (Constitution, 2008). One example is the contextualization of the Agricultural Technology program to local crops, integrating innovation and ancestral practices. The article highlights the need to link technological aspects with the social sciences, reversing the historical separation that impoverishes both fields (García Palacios et al., 2001, p. SP). The article details the distinctive elements of the social linkages of ISTTs and their role in social transformation.

Social projection of curriculum outcomes

The link with society is an essential political-academic tool for Higher Technical and Technological Institutes (ISTT), as it articulates teaching with research (Beltrán Ayala and Ortega Sánchez, 2021, p. 5). The social projection of the curriculum is evident when learning and academic products directly benefit the community, mainly through integrated links as a requirement for graduation (LOES, 2018; CACES, 2021). The correct implementation of engagement can enhance human work through the integration of biological, physical, and technological advances (Schwab, 2016, p. 43). Activities such as pre-professional internships and community projects allow for the application of knowledge in real contexts, demonstrating social impact. Employability and employer satisfaction reflect the effectiveness of the curriculum, with documented success stories of graduates promoting local technological solutions. Integrative projects strengthen institutional legitimacy and generate feedback. The inclusion of topics such as ethics and sustainability trains socially committed technicians. In conclusion, the social projection of the curriculum is fundamental to educational quality, transforming reality through professionals who contribute concrete solutions to local and national development (CES, 2019).

Educational quality management: application in technical and technological education

Educational quality management encompasses the institutional processes, practices, and strategies for planning, evaluating, and continuously improving the effectiveness, relevance, and equity of the education offered. In higher education, particularly in Higher Technical and Technological Institutes (ISTT), quality management is distinguished by its focus on practical relevance, competency-based training, and the social impact of learning outcomes (CACES, 2021; Jiménez González et al., 2022). For a comprehensive understanding, it is pertinent to analyze the contributions of classic authors on quality management, initially formulated in the industrial sector, and examine their adaptation and reinterpretation in the educational field.

Classic approaches to quality applied to education

Educational quality management in Higher Technical and Technological Institutes (ISTT) must integrate classic principles adapted to the Latin American context, prioritizing people and ethical commitment. Quality manifests itself in academic, administrative, infrastructural, and results dimensions (CACES, 2021), and the LOES (2018, art. 6) defines it as a continuous and participatory pursuit. The implementation of quality assurance units is common (LOES, 2018, art. 95). Quality practical teaching requires teachers with experience and pedagogical training in active methodologies and educational technologies (Cano & Díaz, 2019; CACES, 2021), with knowledge of the CTS approach to teaching being crucial. Quality also encompasses student well-being and the response to the social mandate of ISTTs. CTS training is necessary for society to make informed decisions about technology, promoting literacy in line with a new image of science and technology (García Palacios et al., 2001, p. 149).

Link to the Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs) of the 2030 Agenda provide global guidance for balanced development. SDG 4, focused on inclusive and quality education, directly connects Higher Technical and Technological Institutes (ISTT) with target 4.3, which promotes equal access to technical and higher education (United Nations, 2015). The Sustainable Development Goals (SDGs) of the 2030 Agenda, conceived as a global framework for action to address the planet's most pressing challenges, provide a comprehensive roadmap toward development that harmonizes economic, social, and environmental dimensions. Within this ambitious plan, SDG 4 stands as a fundamental pillar, focusing on ensuring inclusive, equitable, and quality education for all. This transcendent goal recognizes the crucial role of education as a driver of individual and collective

progress, as well as its transformative capacity to build more just, peaceful, and sustainable societies.

In this context, the connection between SDG 4 and Higher Technical and Technological Institutes (ISTT) is directly and essentially manifested through target 4.3. This specific target urges United Nations member states to ensure equal access for all men and women to affordable, quality technical, vocational, and higher education, including university education (United Nations, 2015). By their very nature and mission, ISTTs are key players in achieving this particular goal. These institutions play a vital role in training highly skilled technical professionals and technologists with the skills and competencies necessary to drive economic and social development in various productive sectors. By offering relevant, high-quality training programs, ISTTs contribute directly to expanding lifelong learning opportunities and reducing inequalities in access to higher education. In this way, they strengthen individual and collective capacities, foster innovation, and promote employability, all of which are essential elements for achieving sustainable and inclusive development within the framework of the 2030 Agenda.

Key actors in educational quality: roles and commitments

The educational quality and social impact of ISTTs are based on the coordinated commitment of authorities, teachers, students, the productive sector, the community, and the State, which together form an ecosystem for continuous improvement. Authorities lead strategic planning and accountability. Teachers ensure academic quality through updating and active participation. Students contribute through practice and feedback. The productive sector offers curriculum relevance with internships and advice. The community legitimizes the impact and guides the projects. The State defines policies and finances public ISTTs (Núñez, 2022). This collaborative model, based on the quadruple helix (academia, business, State, and society), sustains a culture of quality and shared social outreach. In conclusion, the essential role and joint commitment of each actor drives institutional development and its transformative impact on the community.

Transfer of results to society: a virtuous cycle of continuous improvement, informed decision-making, and sustainability

The transfer of results to society is a pillar of the social outreach of Higher Technical and Technological Institutes (ISTT), manifesting itself in tangible impacts such as job placement and advice to entrepreneurs. This cyclical process of continuous improvement includes the internal generation of results, their external application, feedback on social impact, evidence-based institutional improvement, and institutional strengthening (Beltrán Ayala & Ortega Sánchez,

2021, p. 5). The institutionalization of feedback mechanisms is crucial for the sustainability of the cycle, transforming continuous improvement into an institutional development strategy. The transfer of results, including technological ones, requires training in the CTS approach (García Palacios et al., 2001, p. 149), benefiting the community and revitalizing ISTTs as key agents of development, guaranteeing quality, legitimacy, and sustainability.

Technology in education: a means, not an end

Technology has transformed education, particularly in technical and technological institutes, where its use is fundamental. While tools such as virtual classrooms, simulators, and artificial intelligence diversify learning, it is crucial to remember that technology is a pedagogical means, not an end (UNESCO, 2023). UNESCO (2023) warns that ICTs do not replace human interaction or pedagogical support, which are essential aspects of technical training for the development of practical skills and values that require direct mentoring. When implemented correctly, technology improves educational quality by facilitating flexible access to content, complementing training with simulators, personalizing learning, and optimizing institutional management. Its role was crucial during the pandemic, although it revealed limitations in practical areas, consolidating the hybrid model as a student-centered alternative. In quality management, technology streamlines the monitoring of indicators, automates processes, and bases decision-making on data; educational analytics, for example, helps identify dropout risks and improve feedback. However, technological integration requires teacher training, technical support, curriculum adaptation, and digital inclusion, in line with SDG 4. Equitable access and meaningful use are pillars of quality education. The human factor remains paramount, with teachers acting as mentors, guides, and facilitators. Even in digital environments, learning requires reflection, ethics, and support. Technology should complement, not replace, the human dimension in the educational process. ISTTs should lead the way in the critical and humanized use of technology, promoting innovation without neglecting the comprehensive development of students.

Conclusions

Higher Technical and Technological Institutes (ISTTs) are key players in the science-technology-society (CTS) framework, as they are dedicated to training human talent with applied skills and promoting technological and social solutions adapted to the needs of their context. Their social mission is strengthened by educational quality management that adopts a critical and transformative perspective, which has a beneficial impact on the communities and productive sectors in which they operate. Although they share with universities and conservatories the objective of establishing their own institutional identity and contributing to the general welfare, as established by

the Constitution of the Republic of Ecuador (2008), the eminently practical and flexible nature of ISTTs gives them the ability to respond more quickly to the demands of society.

The relevance of their curricula, based on exhaustive assessments of the environment and constant interaction with various external actors, is an essential factor in ensuring the quality of the education they provide. The mandatory incorporation of social engagement in the curriculum is an important step forward; however, to ensure its effectiveness, it is necessary to consolidate the application of dynamic teaching methods, such as project-based learning (PBL) and service learning, as well as to establish continuous assessment systems that make it possible to quantify its true impact. It is crucial to understand that quality in technical and technological higher education must go beyond mere compliance with the criteria established for accreditation, becoming an intrinsic element of institutional culture. This is achieved through the active participation of all levels of the educational community in the processes of self-evaluation, continuous improvement, and strategic planning. The current regulatory framework in Ecuador, comprising the Constitution, the Organic Law on Higher Education (LOES), and the Academic Regulations (RRA), provides a solid basis for quality assurance and the promotion of the social outreach of ISTTs. Despite this, significant challenges have been identified in its effective implementation, especially in those institutions with limited resources. The ISTT have considerable potential to promote alignment with the Sustainable Development Goals (SDGs) set out in the 2030 Agenda, contributing significantly to the achievement of SDG 4, related to quality education, as well as other goals linked to decent employment, social equity, and the promotion of innovation. To realize this potential, it is considered essential to improve the visibility of the work carried out by ISTTs through the preparation and dissemination of detailed reports that explain their contribution to the 2030 Agenda. These reports should incorporate specific indicators of inclusion, sustainability, and gender equity in their planning and in the presentation of their results.

Quality is conceived in this context as a collective construction, where collaboration and synergy between institutional authorities, faculty, students, the productive sector, the community at large, and the State are essential elements. This active collaboration among key actors is indispensable for institutional development and for maximizing its transformative impact on society. The effective transfer of the knowledge generated and the solutions developed to the environment produces tangible positive impacts that, in turn, feed back into and strengthen the institution. This virtuous cycle of training, knowledge application, impact generation, and feedback must be formalized through the

implementation of robust impact assessment mechanisms and the adoption of decision-making processes based on solid evidence (Scorsetti et al., 2021).

It is important to emphasize that technology should be used as a resource to achieve educational objectives, implemented in a pedagogically appropriate, ethically considered, and essentially inclusive manner, as indicated by UNESCO (2023). ISTTs have the potential to spearhead educational innovation initiatives, without forgetting that students and teachers are the main actors in the teaching-learning process. This research aims to provide a detailed understanding of the inherent connection between educational quality management and the social impact of Higher Technical and Technological Institutes in the Ecuadorian context. The goal is to establish a solid conceptual framework that will enable institutions to improve their training and outreach procedures, thereby optimizing their contribution to the social and productive development of the nation. It also seeks to identify effective strategies to strengthen the relevance of curricula, the implementation of innovative teaching practices, and the measurement of the social impact of outreach activities. Finally, the aim is to offer concrete recommendations to educational authorities and ISTTs themselves for the formulation of policies and the adoption of practices that promote a culture of quality oriented towards social transformation and the fulfillment of the Sustainable Development Goals.

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Analysis of predictors of academic performance in mathematics: a case study

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Introduction

Identifying the predictors that influence academic performance in mathematics among high school students remains an ongoing challenge in educational research. Mathematics plays a crucial role in fostering soft skills such as problem-solving and logical reasoning, while also promoting mental discipline essential for understanding other subjects (Kandemir *et al.*, 2024). Previous studies have identified several factors that impact students' academic achievement in mathematics, including socioeconomic status, gender, parental education level, and students' self-efficacy beliefs about their ability to succeed and obtain positive outcomes (Abín *et al.*, 2020). A student's previous performance in mathematics can also shape their perception of their own capabilities to attain academic success (Semeraro *et al.*, 2020). In addition, parental involvement and educational background may influence their children's mathematical performance and development (Liu *et al.*, 2024).

Learning mathematics among secondary school students presents a range of difficulties and challenges, as identified in preliminary studies. These challenges can be categorized into three main types: pedagogical barriers, student-related factors, and systemic issues within the educational system.

Pedagogical challenges include difficulties in teaching abstract concepts, adapting instruction to students' learning levels, limited technological infrastructure (Güner & Çermik, 2022), and issues related to teacher preparation and motivation (Kisakali & Kuznetsov, n.d.). Student-related factors involve inadequate study habits and lack of perseverance (Haokip & Saroh, 2022), conceptual difficulties and low engagement (Junaid *et al.*, 2023), as well as negative attitudes and diminished motivation toward mathematics (Güner & Çermik, 2022).

Systemic issues within the educational system include several aspects: limited access to teaching resources, infrastructure, and services (Peter *et a*l., 2014); an overloaded and frequently revised curriculum (Güner & Çermik, 2022); an assessment approach that focuses solely on cognitive mastery, neglecting creativity and data interpretation (Kakai, 2012); and the persistent need for

information and communication technology (ICT) infrastructure to support learning, especially following the pandemic (Mukuka *et al.*, 2021).

Based on the considerations outlined above, the present study is justified. The analysis of academic performance within educational institutions has gained increasing importance in the context of data-driven decision-making, particularly in developing regions such as Latin America. In Colombia, the public education system faces unique challenges that directly impact student performance, making it essential to understand the complex interplay of educational factors through systematic data analysis. At the international level, the Programme for International Student Assessment (PISA) serves as a recognized benchmark for the country. Analyses of the results in mathematics, reading, and science from recent assessments (2018 and 2022) indicate a declining trend in comparison with other nations (PISA 2018 Results (Volume I), 2019; ICFES, 2020; ICFES, 2023; MEN, 2023). Nationally, the main reference point is the SABER 11 examination, formerly known as the ICFES test. It evaluates high school graduates in key areas, including critical reading, mathematics, social sciences, natural sciences, and English. Analyses of SABER 11 results from public schools over the past five years (2019 to 2023) reveal persistent weaknesses in mathematics performance (Bustamante, 2022; ICFES, 2022; ICFES, 2023; MEN, 2023; Ramírez, 2021; Villegas, 2023).

Case Study

In the context of Cartagena de Indias (Colombia), the results of the SABER 11 tests between 2018 and 2022 reveal an unpromising outlook for public educational institutions, both urban and rural. These institutions have shown a consistent decline in scores relative to the maximum score of 500 points: 2018 (240 for urban and 209 for rural), 2019 (233 urban, 203 rural), 2020 (233 urban, 206 rural), 2021 (228 urban, 201 rural), and 2022 (232 urban, 205 rural) (Umayor; Secretaría de Educación de Cartagena, 2023).

In 2024, SABER 11 results showed an improvement for official or public institutions, reflected in an increase in the Global Educational Quality Index (on a scale from 0 to 100), which rose from 60.1 in 2023 to 61.4 in 2024. However, this figure remains below the national average of 68.1 (Cartagena Cómo Vamos, 2025). Against this backdrop, the present research is based on an intervention carried out in 2022 at Institución Educativa Santa María, a public school located in the historical and North Caribbean district, Communal Unit #3, in the Santa María neighborhood. The fieldwork included a previously validated 33-item survey administered to a sample of 205 high school students from grades 9 through 11.

The case study involved 205 students from grades 9 to 11. The variables

analyzed were grouped into the following categories: 1) Sociodemographic dimension: gender, grade-group, nationality, age, socioeconomic stratum, population group, parental education level, among others; 2) Academic dimension: grade retention, subjects with learning difficulties, academic performance across the three academic periods, and final grade; 3) Technological resources dimension: availability of technological tools; 4) Institutional dimension: participation in the school feeding program, access to institutional resources, and feedback received. The main findings obtained from the data analysis process are presented below.

The key sociodemographic characteristics of the sample are summarized as follows:

1. Gender distribution: Approximately 57% of respondents identified as female, and about 43% as male, as shown in Figure 1.

2. Age: The average age of participants was approximately 15.38 years (SD = 1.29), indicating that most students were between 14 and 16 years old (Figure 2).

3. Socioeconomic status: The majority of students belonged to lower socioeconomic strata, with 44% in stratum 1 and 40% in stratum 2. Only a small percentage came from higher strata (Figure 3).

4. Nationality: Most respondents were Colombian (approximately 80%), while Venezuelan students represented about 20% of the sample. A small number of responses were unspecified (Figure 4)

Figure 1. Gender distribution of students.



Figure 3. Socioeconomic stratum.

Figure 2. Age distribution of students

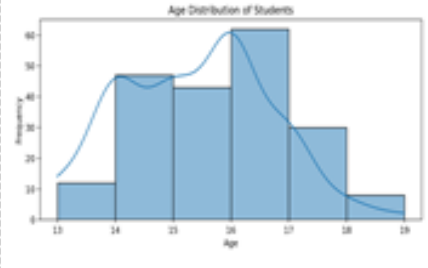
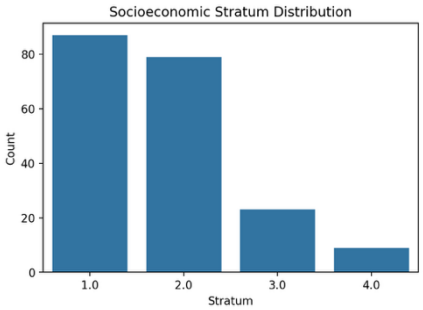
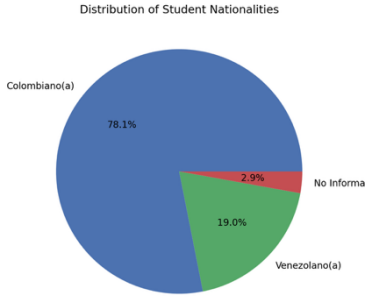


Figure 4. Nationality distribution





The analysis of academic performance across the three academic periods (P1, P2, P3) and the final grade (PF) in mathematics yielded the following results (see Figure 5): the highest mean score was recorded in P2 (M = 3.25), followed by the final grade PF (M = 3.22). The lowest means were observed in P1 (M = 3.18) and P3 (M = 3.18), although these differences were minimal compared to PF. These results suggest a slight improvement in performance during the second period, with consolidation reflected in the final average. Regarding variability, standard deviations were similar across all periods, indicating a relatively homogeneous distribution of scores. However, P2 exhibited the greatest variability (SD = 0.77), followed by P1 (SD = 0.76). The lowest variability was observed for PF (SD = 0.72), suggesting that final results were more consistent among students. Concerning percentiles, the median (50th percentile) remained consistent across all periods and the final grade (PF), at 3.3, indicating stability in central performance. The 25th percentile (3.0 in P1, P2, and P3) and the 75th percentile (3.6–3.7) suggest that most students maintained performance within a range of 3.0 to 3.7, corresponding to acceptable to good achievement levels. Regarding extreme values (minimum and maximum), the lowest grade was 1.0 in all periods and PF, reflecting that some students exhibited critical performance. Maximum grades showed slight variations: P2 (4.7) and PF (4.8) recorded the highest values, indicating potential improvements for some students toward the end of the academic year. Meanwhile, P1 and P3 reached the maximum possible score of 5.0, suggesting that top performance is attainable at any stage of the year.

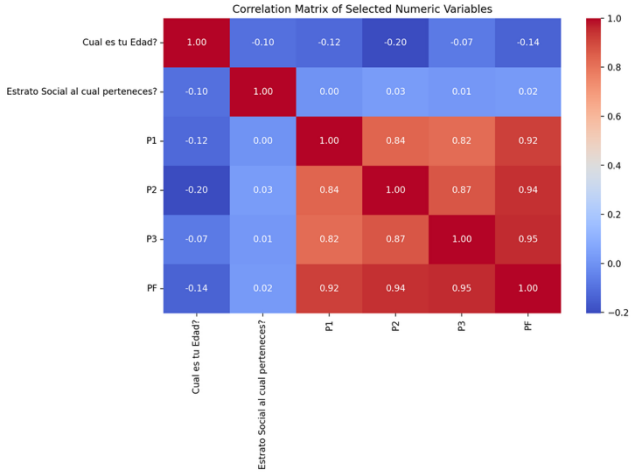
Figure 5. Descriptive Analysis of numeric variables.

	P1	P2	P3	PF
count	205	205	205	205
mean	3.1834146341	3.2502439024	3.1848780488	3.2180487805
std	0.7630678848	0.7701301386	0.7472928986	0.7193516263
min	1	1	1	1
25%	3	3	3	3.1
50%	3.3	3.3	3.3	3.3
75%	3.6	3.7	3.6	3.6
max	5	4.7	5	4.8

The correlation matrix for the selected numerical variables revealed strong positive relationships among the academic performance variables (P1, P2, P3, and PF), with correlation coefficients approaching 1. This suggests that these variables tend to increase or decrease in tandem. In contrast, the variables *age* and *socioeconomic stratum* exhibited weak or negative correlations with the performance variables, suggesting a less direct association.

The heatmap (Figure 6) visually reinforces these findings, as darker shades correspond to stronger positive correlations among the P variables.

Figure 6. Correlation matrix.



Additional correlations between various predictors and final grade (PF) performance were examined, yielding the following observations:

- Students who dedicate 3 to 4 hours per week to academic activities tend to achieve the highest average grades, whereas those studying 8 to 9 hours show slightly lower averages. This pattern suggests that moderate study time may be optimal, or alternatively, that students facing greater academic difficulties allocate more time to studying.
- Family support did not exhibit a strong positive effect; in fact, students reporting no family support had marginally higher average grades, though the difference was minimal.
- Students who have never repeated a grade outperformed those who have experienced grade retention.
- Internet access was associated with higher academic performance compared to students without access.

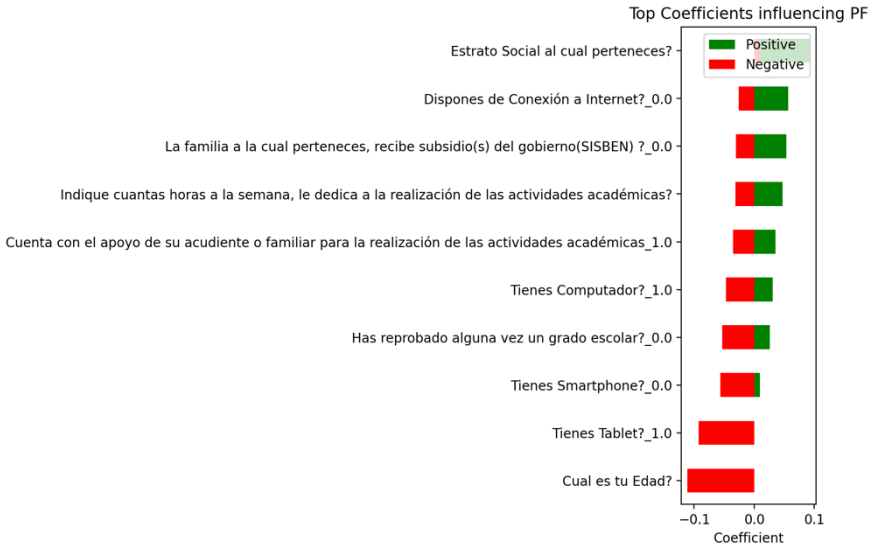
The analysis of differences in final grades (PF) by nationality was conducted using the non-parametric Kruskal–Wallis test, which is suitable for non-normal distributions and

unequal sample sizes. The results, show that the median and most of the distribution for the Venezuelan group fall below those of the Colombian group, with some low outliers extending the lower tail. However, the test yielded a statistic of H ≈ 3.09 and a p-value of ≈ 0.214, which exceeds the 0.05 significance threshold. Therefore, the null hypothesis of equal medians cannot be rejected. Consequently, while descriptive differences between groups are apparent, these differences are not statistically significant.

Predictive Analysis

At this stage, two predictive models were applied: multivariable linear regression and Random Forest. For the linear regression model, Figure 7 presents the ten variables with the greatest potential influence on final grade (PF) performance in mathematics.

Figure 7. Top Coefficients influencing PF



The test R2 value was essentially zero, indicating that this simple linear model could not reliably predict final performance (PF) based on the selected background variables. Figure 8 displays the ten coefficients with the largest absolute values (green = positive influence; red = negative influence). Although certain factors appear to exert some effect, the overall predictive power of the model is negligible. Therefore, individual coefficients should not be overinterpreted. A Random Forest machine learning model was employed, as this technique is well-suited for identifying complex, non-linear patterns in data. The model revealed that a student's final grade (PF) is not driven by a single factor, but rather by a combination of academic, personal, and socioeconomic variables.

Based on the Random Forest analysis, the following factors emerged as the most significant predictors of academic performance:

- Subjects of Difficulty: The specific subjects a student struggles with represent the strongest predictor, indicating that difficulties in core subjects substantially impact overall grades.

- Age: Student age was a relevant factor, suggesting that older students—often due to grade repetition—may face distinct academic challenges.

- Commute Time: The duration of travel to school showed a strong association with academic performance, with longer commutes potentially linked to fatigue and reduced study time.

- Grade and Group: Class grouping appeared as a strong predictor, possibly reflecting variations in teaching practices, peer dynamics, or curricular differences across groups.

- Institutional Resource Use: Utilization of school resources (e.g., library, computer labs) was an important indicator, suggesting that students who access these resources tend to be more engaged and achieve better outcomes.

- Weekly Study Hours: The number of hours dedicated to studying each week strongly influenced performance, as expected.

- Teacher Feedback: Receiving feedback and guidance from teachers was highly influential, highlighting the critical role of teacher-student interaction.

- Living Situation: Household composition correlated with academic performance, possibly reflecting family support structures.

- Population Group: The population category with which a student identifies was associated with academic outcomes, potentially reflecting broader socioeconomic influences.

- Transportation Method: The means of transportation used to reach school also ranked among the top predictors.

To identify these key factors, a RandomForestRegressor model was trained on the dataset. This algorithm evaluates all variables concurrently to capture complex, non-linear relationships with the final academic performance (PF). The *feature importance* score for each variable reflects its relative contribution to predicting the final grade. To ensure the validity of the model and prevent data leakage, variables that could directly reveal the outcomes such as periodic grades (P1, P2, and P3)—were excluded from the analysis.It is important to note that this analysis identifies associations within this specific dataset and does not establish causal relationships. Nevertheless, the findings offer valuable, data-driven insights into the multifactorial nature of academic achievement.

Conclusions

This study explored the multifaceted factors shaping high school students' mathematics performance at *Institución Educativa Santa María* in Cartagena de Indias, Colombia, within a context marked by declining results in national and international assessments (PISA and SABER 11). Identifying key predictors emerged as essential for informed, data-driven educational strategies.

Findings revealed a balanced gender distribution and age alignment with the grade level, though most students belonged to low socioeconomic strata (1 and 2). Overall performance ranged from acceptable to good, with stable variability; however, some cases reflected critical achievement levels. Correlation analyses indicated strong associations among grades across academic periods, whereas variables such as age and socioeconomic status showed weak or negative relationships with performance. Study habits also mattered: students dedicating 3–4 weekly study hours achieved the highest results, and internet access was linked to improved outcomes. Although descriptive differences were observed between Colombian and Venezuelan students, statistical testing (Kruskal–Wallis) confirmed no significant disparities.

Advanced modeling through Random Forest identified the most influential predictors of final performance, demonstrating an advantage over linear regression by capturing the complex interplay of academic, personal, and socioeconomic factors. These results highlight that academic achievement is not shaped by isolated elements but by interconnected variables requiring holistic attention.

While causal inference was beyond this study's scope, the insights generated provide a foundation for evidence-based, equitable, and student-centered educational interventions. Future research should incorporate qualitative approaches and evaluate the impact of targeted pedagogical strategies to strengthen mathematics learning outcomes and reduce persistent performance gaps.

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Digitization of processes in the modernization of public administration

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Introduction

The modernization of public management, especially in decentralized contexts in Latin America, requires more than just the adoption of technologies: it demands a scientific basis that integrates social, regulatory, and strategic perspectives. Digital transformation must be understood as a complex process that, in addition to improving operational efficiency, contributes to the generation of public value and institutional consolidation. The social sciences have emphasized the importance of developing applied research that connects digital tools with the structural challenges of subnational governments, where gaps in capacity, coordination, and legitimacy persist (Barros & Bores, 2024).

In this context, the digital transformation of the public sector has been established as the strategic axis for redefining state governance and responding to growing citizen demands for efficient, transparent, and user-oriented services. The digitization of administrative processes has opened up new opportunities for states to improve their operational efficiency, lower their prices, eliminate unnecessary repetitions, and facilitate citizens' access to public services. According to Mego Torres et al. (2024), digitization is not only a matter of technology, but also an institutional strategy aimed at redesigning processes, training staff, and establishing new models of governance. Therefore, the

transition from a bureaucratic to a digital state would provide the articulation of innovative regulatory approaches, the identification of interoperable frameworks, and the promotion of leadership institutions committed to public value. Against this backdrop, this research will clarify the connection between the digitization of processes and state modernization, as expressed in the practice of a municipality in Peru.

Consistent with this conceptual framework, this chapter is directly linked to the Sustainable Development Goals, especially SDG 16 and SDG 9. The former highlights the objectives of strengthening accountable and transparent institutions; the latter aims to promote the use of sustainable infrastructure and the advancement of digital technology. In this spirit, the digitization of processes can be seen as a resource for immediate application through improved institutional traceability, public accountability, and efficiency in service delivery. Success stories in Chile and Uruguay show that a systems-based approach is in line with the vision of digital governance; the use of interoperable platforms, electronic signatures, digital portals for procedures, and electronic document management not only improve administration but also increase citizen satisfaction. However, satisfactory results depend on a holistic approach, a strategic vision, inter-institutional coordination, and an ethical framework for governance (Cabana et al., 2020).

On the international stage, in Europe and Asia in particular, digitization has generated new experiences, but it has also led to constant tensions. For example, while Estonia has managed to "digitize" 99% of its national public services, Spain and Germany have not been able to do so due to the uneven segmentation of subnational state powers, which prevents state platforms from interacting with each other (De Celis Gutiérrez, 2021). Similarly, while South Korea and Singapore have used AI to improve public administration, they have faced ethical dilemmas regarding the massive use of personal data and the automation of state work (Cerezo García & Landa Díaz, 2020). These cases show that successful digitization requires not only technology but also cultural and institutional change to ensure the adaptation and sustainability of the change.

However, despite these advances, a second problem persists on a global scale, which is the sustainability of digital ecosystems. While many states have modern technology platforms, they still lack sustainable mechanisms to effectively integrate various public agencies. According to Mego Torres et al. (2024): "Disconnection is therefore one of the factors which, combined with the insufficient training of state personnel, creates a vicious circle of tension between operational efficiency and labor rights... This is why we are experiencing an additional increase in digital stress and feeling even more resistance to change." Similarly, according to the OECD, "technological efforts must be accompanied

by complex reforms in the structure of the public service. Digital ethics, cybersecurity, and the development of data management and human talent skills must be properly regulated." Therefore, in fact, these global challenges demonstrate that digital modernization is not just a technical goal, but a multifaceted strategy for the transformation of the government sphere.

In many Latin American countries, moving toward digital government has been more complicated than expected. Take the case of Argentina: there have been efforts to open up government through digital platforms, but these attempts have not always been consistent. Political instability, low investment, and regional differences have meant that progress has been half-hearted. As Cormick (2020) points out, technology has arrived, yes, but without a real renewal of institutions, which has left many bureaucratic practices of the past intact. The result: digital services only cover the basics and fail to fundamentally change the way public services are managed.

Consequently, these obstacles undermine institutional legitimacy and significantly reduce the true transformative potential of digitization.

Complementarily, cases such as Colombia and Ecuador have shown progress in the use of technologies such as blockchain, artificial intelligence, and georeferencing in health and safety. However, these developments have not yet been consolidated due to a lack of interoperable regulations and poor coordination between levels of government. According to Blanco Junior & Marguti (2020), digitization continues to be understood as a technical solution rather than a strategic process of institutional change. The region has fragmented digital governance, where "pilot projects" without scalability or sustainability predominate. Without integrated strategies for public innovation, digital leadership, and a citizen-centered approach, digitization risks deepening existing institutional gaps.

Complementarily, countries such as Colombia and Ecuador have shown significant progress in the adoption of technologies such as blockchain, artificial intelligence, or georeferencing in sectors such as health and security. However, these developments have not yet been fully consolidated due to the lack of interoperable regulations and weak coordination between different levels of government. According to Blanco Junior & Marguti (2020), "despite the relevance of digital technology in the public agenda of countries in the region [...] digitization continues to be seen as a technical solution rather than a strategic process of institutional change." This has led to fragmented digital governance, where 'experiments' or "pilot projects" that lack scalability and sustainability predominate. Without integrated strategies for public innovation, digital

leadership, and a citizen-centered approach, digitization risks further deepening existing institutional gaps.

In addition to operational constraints, another key structural challenge is the lack of interoperability between public entities. As Janqui Guzmán (2020) warns, Peru does not have a nationwide digital architecture, which prevents the proper integration of systems and hinders the traceability of processes between institutions. This problem is exacerbated in rural areas, where connectivity is poor and people must travel long distances to carry out basic procedures. Added to this is limited training in cybersecurity, which exposes entities to vulnerabilities and undermines public confidence in the use of state technologies. In this context, digitization is still perceived as a half-fulfilled promise: the advances that exist are scattered and require political coordination, financial sustainability, and a focus on creating public value.

The objective of this chapter has been to analyze how the digitization of processes contributes to modernizing public management in subnational governments in Peru, based on a case study of a provincial municipality. It has been argued that, paradoxically, digital transformation involves much more than the simple incorporation of technologies: it entails a profound redefinition of organizational models, management systems, and the approach to public service. The chapter is structured in six sections. It opens with the theoretical foundations of contemporary public management; then addresses the role of digitization as a tool for transformation; presents a case study; develops a critical discussion; and finally, presents conclusions along with recommendations for future policies and research.

Theoretical foundations of public management and its modernization

From simple administration, public management has evolved into a model focused on generating value, efficiency, and concrete achievements for its beneficiaries. This means that effectiveness, understood as the achievement of objectives, and efficiency, in reference to the perfect leveraging of resources, are two pillars that should never be separated from the assessment of institutional performance. Likewise, public value has taken center stage as the ultimate criterion, understood as the social outcome of the policies implemented, which gives its application the best guarantee that it has been properly implemented. According to Rodriguez López (2023), effectiveness and efficiency can be achieved through mechanisms for measuring them, which can be verified as being more social than technical in personnel and strategic decision-making. This amplified lens allows for better fulfillment of the premises of contemporary public management, which is more oriented toward the governance model in terms of impact, legitimacy, and lasting institutionality.

Within this framework of conceptual evolution, one of the key milestones has been New Public Management: promoted in the 1980s in response to the state's fiscal crisis and criticism of traditional bureaucracy, this approach brought private sector instruments—such as competition, performance monitoring, and decentralization—to the functioning of the state apparatus. However, several studies have also noted that the uncritical implementation of NPM can alter public goals by prioritizing operational efficiency over equity and participation. Cormick shows that the adoption of the model in OECD and Latin American countries has achieved improvements in technical terms, but has required institutional and regulatory adjustments to avoid a regressive collapse. Consequently, New Public Management continues to be an essential reference point, although it is not sufficient for the construction of truly democratic and inclusive contemporary management models.

Just as a reaction to the limitations of NPM, more recent proposals such as collaborative governance and open government have emerged. These models recognize that public problems are complex and that the state cannot solve them alone. Therefore, they promote shared management with other actors—citizens, social organizations, the private sector—under principles such as transparency, accountability, and active participation. According to Garfias Dávila et al. (2024), we are moving toward more horizontal forms of public administration, where access to information and digitization play a key role. In this scenario, open government not only improves institutional quality, but also strengthens people's trust by allowing them to monitor, propose, and innovate together with the state. It is a change in logic: the state is no longer the only actor, but a facilitator of shared solutions.

International cooperation has also played an important role in the modernization of the State. Organizations such as the OECD have published recommendations to improve digital governance, while the IDB has financed studies and open government strategies. For its part, ECLAC has promoted digital agendas that include connectivity, open data, and inclusion. These initiatives not only offer technical guidance, but also encourage the exchange of experiences and the harmonization of policies between countries. De La Cruz Ccora et al. (2024) point out that following these recommendations helps to improve public services, strengthening accountability and putting citizens at the center. Thus, international cooperation becomes an engine for countries to move toward a more modern and efficient state.

In Peru, the modernization of the state is governed by the Framework Law on Modernization (Law No. 27658), which promotes efficiency, service quality, and citizen participation. This policy is led by the Presidency of the Council of Ministers, through the Secretariat of Public Management, and has the technical

support of CEPLAN. One of the main challenges is to apply these changes in regional and local governments, where there are often insufficient technical and financial resources to adopt digital tools. Even so, important steps have been taken, such as the implementation of a process-based approach and the use of electronic platforms that allow indicators to be monitored and the traceability of public services to be improved (Garfias Dávila et al., 2024).

From the synthesis of the above approaches, we can affirm that, first of all, the way to generate public value in contemporary public management is not limited to the letter of the law, nor to a technical or control system. However, Cabana et al. (2020) point out that "control" itself, when linked to a culture that promotes continuous improvement and skills development, effectively generates public value. In other words, the modernization of the state requires systemic and coordinated processes, where planning, evaluation, and knowledge management are linked. They also point out that the culture of transformation must also focus on human talent management and the ability to adapt to changes in context, while always ensuring inclusion, equity, and sustainability. Ultimately, current theoretical approaches must be reflected in a flexible, empowered, and socially engaged public administration that expresses direct concern for democratic consensus and collective well-being.

Figure 1. *Theoretical foundations of public management and its modernization*



Note: The figure illustrates how public management has evolved: we started with a traditional bureaucratic model, focused on rigid procedures, and have arrived at more modern approaches such as collaborative governance, open government, and the creation of public value. This change is not only technical, but also political and cultural. It is no longer just a question of being efficient,

but of gaining democratic legitimacy and putting citizens at the center of all state decisions.

Digitization as a tool for modernization

When we talk about digitization in the public sector, we are referring to moving processes and data from paper to digital. Automation goes a step further, using technology to perform tasks without human intervention. And digital transformation involves a more profound strategic change, modifying structures, roles, and services, always with citizens at the center. Although they are related, these concepts are not the same. For example, digitizing a file does not necessarily change how an institution operates. Digital transformation, on the other hand, completely redefines how things are done. Recent research shows that digitization improves efficiency, but it is digital transformation that drives innovation and institutional resilience (Charles et al., 2023; Szelągowski et al., 2022). In this process, ERP and BPM tools are essential. ERP systems allow functions such as finance, human resources, and logistics to be integrated into a single platform, improving efficiency and process control. For its part, BPM helps to continuously analyze and improve processes, which is especially useful in contexts where the organization is still in an early stage of development. The success of these tools depends on their adaptation to the capabilities of each institution and the active participation of key actors (Dutra et al., 2022; Szelągowski et al., 2022).

Digital signatures also play a key role. They ensure the validity and authenticity of electronic documents, streamline procedures, and reduce administrative costs. In addition, interoperability platforms allow different public entities to share information automatically, avoiding duplication and shortening response times. Recent studies show that these tools not only make services more efficient, but also improve citizens' perception of the transparency and accessibility of the State (Gunawan et al., 2020; Vergel-Arévalo et al., 2023). Another important piece is the ISO 30301 standard, which provides a framework for document management aligned with the objectives of each institution. This standard improves traceability, accountability, and the preservation of institutional memory. In digital scenarios, ISO 30301 ensures that documents meet standards of authenticity, reliability, and accessibility. In addition, it harmonizes archival practices with technological frameworks such as COBIT or ITIL (Eito-Brun & Calleja-Aliaga, 2020).

For its part, ITIL offers best practices for managing technology services efficiently. Its application helps align the needs of citizens with the internal processes of the State, especially in contexts where there is interoperability. Recent research shows that ITIL, combined with interoperable platforms,

improves incident response capabilities and ensures the continuity of digital services (Alratrout et al., 2022; Saragih & Nasution, 2024).

The COBIT framework, on the other hand, provides principles for ensuring good technology governance. Its approach seeks to align technology with institutional objectives and generate public value. In digital contexts, it helps define controls, assess risks, and comply with standards. Its implementation has been shown to improve decision-making based on reliable data (Nzeako et al., 2024; Robayo & Villarreal, 2020).

Case study: The Public Managers Corps in Peru and institutional digitization

In Peru, the "Public Managers Corps" program promoted by SERVIR has been key to modernizing the state apparatus with high-level technical talent. Under the Civil Service Law, these managers have helped introduce digitized processes, improve interoperability between institutions, and implement performance evaluations. Thanks to their work, simplification and digital transformation processes have been accelerated in several ministries and regional governments. However, the structural impact has been limited by obstacles such as resistance to change, lack of real interoperability, and high staff turnover (Martínez Puón, 2020). This case shows that when technical leadership is combined with digitization, public management can improve significantly. In addition to its coordinating role in strategic public sector management, the Public Managers Corps has promoted concrete digitization initiatives in subnational governments with limited technical capacity. It is unthinkable that in regions such as Arequipa, Cusco, and La Libertad, CGP managers have led the implementation of integrated document management systems, online citizen service platforms, and budget process automation. Despite the progress made, recent studies demonstrate the need to institutionalize digital processes beyond the mandate of each manager, as well as to ensure sustained investment in technological infrastructure and training for local staff (Garfias Dávila et al., 2024). Nevertheless, this highlights the urgent need to coordinate digital transformation with long-term public policies focused on decentralization and modernization of the state.

An additional dimension of the CGP's impact on institutional digitization lies in its impact on intergovernmental coordination between different levels of government. In this regard, various reports have pointed out that public managers not only strengthen the internal management of the entities where they operate, but also promote hierarchical relationships with other sectors of the State that enable the activation of interoperability and information exchange processes. This capacity is essential to enable the implementation of extensible

digital platforms such as the State Interoperability Platform (PIDE) and results-based management systems coordinated with the MEF. However, the institutionalization of these capacities depends on the institutional impacts generated not being diluted by staff turnover. For this reason, the presence of public managers must be accompanied by specific knowledge management plans and institutional scaling mechanisms (De la Cruz et al., 2024; Garfias Dávila et al., 2024).

In summary, the experience of the CGP in Peru shows that institutional digitization is not developed solely on the basis of technological solutions, but requires institutionalization processes based on technical leadership with the capacity for coordination, strategic vision, and commitment to improving public service. Although the implementation of these digital tools has improved operational efficiency and transparency, their sustainability will depend on processes that transcend the mandates of leaders to generate an organizational culture that values innovation. Likewise, the need to expand these practices to subnational governments reveals the importance of reducing territorial management and digital gaps. Consequently, the case of the CGP will reinforce the importance of focusing on strengthening human resources in digital transformation policies that are centered on their beneficiaries, aligned with international standards, and have a systemic vision of state development.

Critical reflection

Progress in digitization in Latin America has been mixed: there have been gains in efficiency, but many challenges remain. Tools such as online procedures and document management systems have improved turnaround times and traceability, but their reach remains limited by the digital divide, lack of political continuity, and lack of institutional coordination. In countries such as Peru, Colombia, and Ecuador, technological integration at the regional and local levels remains a major challenge. As Heredia Pazmiño et al. (2021) point out, the pandemic exposed the fragility of many public administrations and reinforced the urgency of more robust digital governance models. For digitization to have a real impact, it needs to be accompanied by profound and sustainable organizational changes.

A major obstacle is resistance to change, both from public officials and citizens. Many workers see automation as a threat to their role, which makes them adopt digital tools only in appearance. In addition, there is a deficit of digital skills, especially at the middle and lower levels of the administration, which makes it difficult to implement technological solutions effectively. Clavijo (2020) even speaks of a "slowdown in institutional progress" in the region, attributed to a lack of budget and weaknesses in the state's human capital. This reinforces the

need for public policies that focus on continuous training, digital leadership, and good change management.

Another critical aspect that deserves attention is the lack of coordination between digital transformation strategies and multi-year planning processes at the subnational levels of government. In many cases, digitization initiatives operate in a fragmented manner, without being aligned with the Concerted Development Plans or the strategic objectives of the PEI or POI. This disconnect limits the sustainability of technological solutions, reduces their territorial impact, and hinders their financing with public resources. Furthermore, by not being integrated into a long-term institutional development vision, these experiences run the risk of becoming isolated efforts, dependent on individual leadership or temporary external funding. It is therefore essential that the digitization of processes be an explicit part of planning and performance evaluation systems, ensuring their coordination with sectoral and territorial public policies that respond to the real needs of citizens. There is also growing academic concern about whether digitization processes are really accompanied by a substantive improvement in the quality of public services or whether they are being carried out under an agenda that is more governed by efficiency indicators. Indeed, several studies have warned that digital transformation, if not accompanied by a truly citizen-centered approach and participatory evaluation mechanisms, can result in a more automated but not necessarily more inclusive and equitable administration. Along these lines, García Moreno (2021) emphasizes that Latin American countries must design "rapid and systematic evaluations that allow for monitoring not only the technical performance of digital platforms, but also their impact on the equity of what is accessed, citizen satisfaction, and the quality of accountability." A digitization process that is not geared toward creating public value for all segments of the population runs the risk of reproducing existing forms of inequality in digital format.

In this sense, the modernization of public management requires a continuous training strategy, where digital capacity building, institutional strengthening, and educational innovation are key elements in ensuring the sustainability of change. Experiences in Latin America have shown that human capital training processes can be effectively integrated into the digital transformation agenda, thus contributing to reducing gaps, professionalizing public service, and consolidating more resilient and people-centered management models (Turpo-Gebera & Pérez-Postigo, 2021).

Conclusions

Digitizing public management is not just a technical issue: it is a key strategy for modernizing the state and creating public value. As seen in this analysis, concepts such as digitization, automation, and digital transformation are not the same and must be understood according to their scope. Technological tools can improve efficiency, but their success depends on adequate regulatory frameworks, technical leadership, and political will. International standards such as ISO 30301, ITIL, or COBIT offer good guidelines, but they need to be adapted to the context. The Peruvian case shows that technical leadership can make a big difference, but it also makes it clear that isolated individuals or programs are not enough. Digitization must be part of long-term public policies, with investment in infrastructure, institutional strengthening, and human talent development.

Ultimately, digitization cannot be limited to speeding up procedures. It must change the way the state relates to people, always seeking inclusion, equity, and transparency. The challenges ahead involve creating forms of evaluation that measure not only efficiency but also social impact, citizen satisfaction, and the reduction of inequalities. Only then can we speak of a real digital transformation, with public meaning and a vision for the future.

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Online higher education and quality assurance: innovations from community engagement in the CAIO+ USEK-CHILE project

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Introduction

In the context of the new challenges faced by higher education institutions regarding quality assurance in programs delivered in online and blended modalities, community engagement ("Vinculación con el Medio" - VcM) has assumed a leading role as an integrative strategy between academic work, university outreach, and social commitment., university outreach, and social commitment. The incorporation of online modalities in higher education has been widely recognized as a key factor in expanding access and fostering flexibility, particularly for non-traditional students. Evidence shows that e-learning not only supports greater inclusion, but also enhances students' autonomy, participation, and ability to integrate academic learning with personal and professional contexts (Dearnley et al., 2006). This chapter examines how a concrete VcM initiative-the CAIO+ project at Universidad SEK-has contributed to strengthening educational quality processes through a bidirectional and participatory logic, involving the articulation of teaching, applied research, and community work.

The CAIO+ project (Comprehensive Obesity Care Center) was developed between 2022 and 2024 in the undergraduate programs of Physical Activity Sciences and the Higher Technical Program in Physical Training, as an institutional response to urgent social issues such as obesity, sedentary lifestyles, and low perceptions of physical and psycho-emotional well-being. Through community-oriented educational activities, the project aimed not only to intervene in health and quality of life, but also to enhance students' generic and professional competencies through contextualized practices and experiential learning. This perspective is consistent with the approach of Zornoza and Zuluaga (2022), who emphasize that participatory frameworks and citizen empowerment are key to fostering processes of self-management in social and environmental policies, as they generate stronger ties between institutions and communities, enabling sustainable and transformative impacts.

This convergence between academia and territory constitutes a replicable model of sociocultural animation and community engagement that has allowed for the consolidation of positive indicators in terms of satisfaction, participation, and institutional development. Such an articulation aligns with socio-educational intervention approaches that emphasize evidence-based methods, adaptability to diverse social contexts, and the promotion of participation, integration, and social transformation as key axes for improving quality of life (Añaños et al., 2021). In this sense, sociocultural animation can also be understood as a concrete practice of active citizenship, fostering cultural participation, dialogue, autonomy, and shared narratives of cooperation and public coexistence, which reinforce the role of higher education projects in linking academic work with territorial empowerment and social responsibility (Viché, 2024). Moreover, Freire (2005) highlights that education is inseparable from ethics, critical reflection, and dialogue, positioning learners as active subjects in the transformation of reality—principles that are fundamental for quality assurance processes grounded in social responsibility and territorial relevance.

The central question guiding this chapter is: In what ways has the CAIO+ strategy contributed to quality assurance in online and blended education through community engagement, and what impacts has it generated within the university and external community between 2022 and 2024? Accordingly, the main objective is to analyze the effectiveness of the CAIO+ project as a VcM mechanism aimed at continuous improvement, the strengthening of professional competencies, and the consolidation of a culture of quality grounded in ethics and territorial relevance. In this sense, previous studies have emphasized that sociocultural animation represents an integrating strategy that strengthens the link between the educational institution, its teaching staff, and the community, generating a sense of belonging, participation, and shared responsibility that enhances the impact of academic initiatives (Gelvis, 2016).

Previous research conducted by Marcial and colleagues has already demonstrated the potential of university-based intervention programs to strengthen both health and educational outcomes. For instance, studies have shown the effectiveness of structured interventions in reducing perceived stress among health sciences students (Marcial, Villalobos Lara, & Marcial Alamilla, 2024), the positive effects of tailored physical conditioning programs on student well-being and academic performance (Marcial Alamilla & Villalobos Lara, 2023), and the theoretical foundations for advancing management praxis in higher education systems to ensure quality and relevance (Marcial Alamilla, 2021). Taken together, these contributions provide a robust background that situates the CAIO+ project within a broader research trajectory that links health,

education, and advanced management as complementary dimensions of quality assurance in higher education.

The relevance of this study lies in its contribution to current debates on the articulation between quality assurance and community engagement in hybrid educational settings. Through a mixed-methods approach combining quantitative and qualitative data, this chapter provides empirical evidence on how a bidirectional approach—focused on situated learning and community intervention—can serve as a transformative axis for institutions seeking to generate significant impact in their environments and to educate professionals with a strong sense of social responsibility. Thus, the CAIO+ experience is presented as a good practice example that integrates educational, health, and community development strategies under a comprehensive vision of quality in higher education.

The evaluation results of the CAIO+ sociocultural animation project demonstrate sustained growth in the participation of students, faculty, and members of the external community during the years 2022, 2023, and 2024. In the case of students, participation increased progressively: from 100 individuals in 2022, there was a 40% rise to 140 participants in 2023, and by 2024 this number had reached 180, representing an additional 29% increase. This positive trend was also observed among professors and institutional staff, whose participation grew from 30 individuals in 2022 to 42 in 2023 (a 40% increase), and then to 50 in 2024 (an additional 19%). As for the external community, participation rose from 50 people in 2022 to 70 in 2023, reflecting a 40% increase, and finally to 90 in 2024, representing another 29% increase.

Overall participant satisfaction also showed a favorable progression. In 2022, 75% of respondents reported being satisfied with the activities carried out. This percentage rose to 85% in 2023, representing a 13% improvement, and reached 92% in 2024, with an additional 8% increase. The internal consistency of the instruments used to measure satisfaction was evaluated using Cronbach's Alpha coefficient, which yielded a value of 0.89, indicating high reliability of the data obtained through the surveys. These findings reflect not only the consolidation of the project as a space for training and participation but also growing recognition from the beneficiaries regarding its positive effects on health, integration, and well-being. This is confirmed by the INTEGRAUSEK Report (2023), which reported that 82% of respondents indicated the highest level of satisfaction with the activities, while the remaining 18% expressed medium-high levels. Additionally, the First Interinstitutional Seminar on Physical Activity, Disability, and Exercise, held in the same year, gathered 39 participants, demonstrating the project's capacity to convene and articulate initiatives with formative and community impact.

In terms of quality of life, the data collected through surveys and interviews revealed significant improvements in the physical and mental well-being of participants. Among students, reductions in stress levels and improvements in sleep quality were reported, confirmed by instruments applied at the end of each semester. More than 70% of participants rated these indicators positively, reinforcing the validity of the project's approach. In-depth interviews corroborated these results and provided testimonies describing concrete improvements in daily routines, perceived well-being, and emotional states of those involved.

According to the VcM Action Progress Report (October 2023), a reduction of 15% in overweight and obesity rates was observed among students, and 12% among community members who actively participated in CAIO+. These figures were verified through anthropometric measurements taken at the beginning and end of each semester cycle. Additionally, qualitative testimonies indicated that 85% of beneficiaries perceived improvements in their mental health, which translated into a decrease in anxiety levels and a sustained increase in general mood. The Table Tennis Workshop Agreement Report, corresponding to the final activity of the workshop, indicated that 89% of participants highly valued the project's impact on their professional development, as well as on the acquisition of knowledge and skills useful for everyday life. These results align with findings from previous studies such as those by Brown et al. (2013) and Dishman et al. (2006), which demonstrated that regular physical activity positively affects stress reduction, sleep improvement, and the strengthening of psychological well-being.

From an educational perspective, the CAIO+ project also contributed significantly to students' professional training by facilitating the integration of theoretical knowledge into real-life application contexts. According to the Disciplinary Graduate Profile Report (2023), 100% of the surveyed graduates acknowledged that their participation in the project enhanced essential competencies such as leadership, effective communication, and ethical conduct in professional settings. This finding is supported by Kolb's (1984) experiential learning framework, which emphasizes the value of direct experience in the consolidation of learning, and Bandura's (1986) social cognitive theory, which highlights the role of environment and social interaction in the development of skills and knowledge.

In summary, the quantitative and qualitative results obtained demonstrate that the CAIO+ project has achieved its objectives, establishing itself as an effective strategy for sociocultural intervention, practical training, and bidirectional

community engagement. The progress in indicators related to health, well-being, professional competencies, and sense of belonging reinforces its relevance as a replicable and sustainable model within university contexts.

The success of the CAIO+ sociocultural animation project can be attributed to the convergence of several key factors, among which the active collaboration of students, faculty, and members of the external community stands out, as well as the bidirectional approach embedded in the Community Engagement (VcM) strategy. This approach enabled the establishment of meaningful exchanges of knowledge and experiences, which not only enhanced the project's social relevance but also its institutional impact. Indeed, the project contributed to positioning Universidad SEK as a benchmark in community engagement and development strategies, thereby strengthening its academic prestige and social visibility. At the same time, it enriched the quality of the educational process by enabling students to apply theoretical knowledge in real-world contexts and develop academic and professional competencies aligned with the graduate profile.

Another noteworthy aspect was the integration of teaching, community intervention, and research. CAIO+ fostered the generation of empirical data applicable to studies in public health and social development, giving rise to a formative and scientific synergy that reinforced experiential learning and academic production. This dynamic aligns with the conclusions of Viché (2024), who emphasize the importance of active participation and collaboration in educational projects as fundamental elements for improving teaching and learning. In the same vein, Reyes (2023) highlights that citizen participation, when linked to territorial development, constitutes a pending challenge but also a crucial opportunity for strengthening local administrations and achieving more sustainable community impact, reinforcing the idea that higher education projects must integrate academic knowledge with territorial empowerment.

Similarly, the findings of Viché (2024), Reyes (2023), and Zornoza and Zuluaga Gómez (2022) reinforce the idea that sociocultural animation not only enhances participants' quality of life but also promotes the strengthening of cultural identity and community spirit. The project's activities, much like traditional sports or local cultural practices, fostered values such as cooperation, intergenerational respect, and recognition of cultural diversity. This identity-building component, tied to the appreciation of local environments and traditions, places the project in alignment with initiatives that seek social transformation through culture as a core axis of integration and participation.

Among the most prominent success factors was the formation of communities of practice (Wenger et al., 2002), understood as spaces where collaborative learning occurs naturally through joint engagement in shared objectives. In this framework, the participation of students, faculty, and community actors enabled a contextualized approach to addressing pressing issues such as obesity and sedentary lifestyles, fostering a sense of ownership, ethical commitment, and social responsibility among all involved.

However, the implementation of the project also revealed certain challenges that must be addressed to ensure its improvement and sustainability. One of the main obstacles identified was the limitation of physical infrastructure, given the increasing demand for participation. The need for more suitable and better-equipped spaces became evident, not only to ensure participants' safety and comfort but also to allow for the optimal development of activities. Likewise, managing student motivation and sustained engagement over time emerged as a critical component that requires specific strategies for retention and ongoing support.

In summary, the results of the CAIO+ project demonstrate its effectiveness as a strategy for community engagement, community-based intervention, and university-level training. Intersectoral collaboration, bidirectional learning, and thematic relevance in public health have been fundamental elements in achieving its objectives. Moreover, the project has contributed to strengthening institutional identity by positioning the university as a key actor in promoting well-being and community development.

In conclusion, CAIO+ constitutes a replicable model of sociocultural animation that integrates theory and practice, promotes civic empowerment, and generates tangible impacts on the quality of life of its participants. Its territorial, experiential, and bidirectional approach demonstrates that it is possible to consolidate a culture of quality in higher education through contextualized, collaborative, and socially committed strategies. The areas identified for improvement-primarily related to infrastructure and participatory management-represent opportunities to further strengthen the project's long-term sustainability and impact.

Conclusions

The comprehensive analysis of the CAIO+ sociocultural animation project demonstrates its consolidation as an effective strategy for educational and community intervention within the context of higher education. The experience developed by Universidad SEK between 2022 and 2024 has made it possible not only to implement activities aimed at promoting health and well-being, but

also to establish a model of bidirectional community engagement that has generated significant impacts on both the university community and the territories with which it has interacted. The results confirm that sociocultural animation, when systematically integrated into the training processes of programs such as Physical Activity Sciences and the Technical Degree in Physical Preparation, fosters the development of professional, social, and personal competencies in students. The experiential, collaborative, and contextualized approach of the project has made it possible to link theoretical knowledge with situated practices, contributing to the consolidation of meaningful learning in real-life contexts and, in turn, strengthening the ethical and civic commitment of future professionals. This articulation becomes especially relevant in light of the growing challenges posed by noncommunicable diseases such as obesity and overweight, which the World Health Organization (2021) identifies as global public health priorities requiring integrated strategies that combine education, health promotion, and community participation.

From a quantitative perspective, the data collected show a sustained increase in the participation of students, faculty, and members of the external community, along with high levels of satisfaction with the implemented activities. Moreover, significant improvements were observed in health indicators such as reductions in body mass index, decreases in stress levels, and increases in overall physical and emotional well-being. These findings reinforce the validity of the project as an effective strategy to address issues such as obesity, sedentary lifestyles, and low social cohesion in specific community contexts.

The qualitative approach complemented these results by providing an in-depth view of participants' perceptions and experiences. The interviews revealed positive transformations in health self-perception, quality of life, and appreciation for community participation. Notable aspects include a strong sense of belonging, shared identity, and the strengthening of social fabric. These elements align with the core principles of sociocultural animation, such as cooperation, self-management, and the recognition of local culture as a vehicle for social transformation.

From an institutional standpoint, CAIO+ has represented a significant advancement in internal quality assurance processes by concretely and measurably linking professional training with university social responsibility. This intervention model has strengthened the university’s positioning within its environment and promotes the image of an institution committed to population well-being and the holistic education of its students. Furthermore, it has generated empirical evidence useful for academic, curricular, and strategic management decision-making in the involved programs.

Nonetheless, important challenges were also identified that must be addressed for the future development of the project. Among these are the need to improve the available physical infrastructure for implementing activities, as well as to optimize mechanisms for managing student and community participation. It is also suggested to broaden the project's scope to include new communities and other disciplinary areas, in order to diversify its impact and enrich its methodologies from an intercultural, inclusive, and territorially situated perspective.

In short, the CAIO+ project emerges as a replicable model of educational and community intervention that combines theory and practice, participation and social responsibility, health and culture. Its implementation demonstrates that it is possible, from the university sphere, to generate meaningful transformations in communities through well-designed, evaluated, and context-sensitive sociocultural animation strategies. This approach not only contributes to the training of competent and committed professionals but also to the construction of a more cohesive, healthy, and equitable society, in alignment with the contemporary challenges of higher education and sustainable human development.

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Use of neurotechnology as part of therapeutic treatment in children with autism spectrum disorder

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Introduction

The purpose of this chapter of the book is to describe the process of applying neurotechnology in conjunction with traditional therapies in children with autism spectrum disorder between the ages of two and eight. The considerable increase in recent years in the number of children diagnosed with autism spectrum disorder has led specialists from the Institute of Neurosciences and the Roberto Gilbert Children's Hospital, both part of the Guayaquil City Charity Board, to agree on the need for increased care for patients at risk of autism whose diagnosis is confirmed after evaluation. In 2022, more than 4,000 cases were recorded between the two hospitals (Ecuador, 2023). Therefore, qualitative research was conducted using techniques and instruments such as interviews, observation, and the Battelle Developmental Inventory applied to a total of eight children between the ages of two and eight, which together made it possible to measure the different areas of development affected in children diagnosed with this spectrum (Holtmann et al. 2011). The description of this process contributes significantly to science and the community in general, as it addresses a little-explored technology that is already available in our country and in developed countries, mainly due to its application in a neurodevelopmental disorder that has increased considerably in recent years (Hume et al., 2021). One of the main conclusions is that neurotechnology is an invaluable resource in the approach and treatment of different mental health conditions, as it is non-invasive, does not cause injury to the user, and directly stimulates neurons and brain waves, which, in conjunction with traditional therapies, is providing more visible results in less time. The great technological development that has taken place in recent decades makes it necessary for professionals in the field of neurorehabilitation to receive specific training on the use and indications of all these new systems. It is important to raise awareness, not only among parents of children diagnosed with autism spectrum disorder, about the existence of brain training, such as therapeutic transcranial stimulation and neurofeedback, which are part of the rehabilitation program for cognitive processes such as language, attention,

memory, and reasoning, but also to share this innovative program on the rehabilitation of these cognitive processes with colleagues in the mental health field, thus optimizing the intervention for this growing population of children (Castagnola and Castagnola, 2021).

Autism spectrum disorder and neurotechnology

For the purposes of this chapter, the term autism spectrum disorder will be used. There are currently many definitions of this condition, which highlight the presence of different neurodevelopmental impairments, such as adaptive capacity, social skills, communication, behavior, and in some cases, global developmental delay. It is important to note that not all children diagnosed with ASD exhibit the same signs and symptoms and the same impairments in the areas mentioned (Kouijzer et al., 2001). Similarly, there are different degrees of impairment and intensity of symptoms, with some cases of autism spectrum disorder affecting cognitive processes but with behavioral or adaptive difficulties, or vice versa. Those diagnosed with severe and moderate degrees of impairment are affected in most areas, limiting their participation in daily life, their independence, and their functionality (Pineda et al., 2014).

On the other hand, we have the definition of the term neurotechnology as the existence of technological equipment aimed at the stimulation, evaluation, and study of the brain, such as brain training or gymnastics, which in this research is a process that includes two stations through which the user receives stimulation (Gómez et al., 2020). The first station consists of the application of transcranial therapeutic equipment, whose structure is like a helmet with electrodes located in specific areas of the brain, such as the prefrontal cortex and other lobes of the brain, which together are responsible for the proper functioning of the areas affected by autism spectrum disorder. This equipment has certain protocols for treating different mental health disorders and illnesses, so it is necessary to have a diagnosis from specialists confirming the presence of Autism Spectrum Disorder before using this equipment. The duration of this session lasts around fifteen minutes at the beginning, which, as the child adapts to the session, will increase to a duration of thirty to forty minutes (Van et al., 2021).

Described 30 years ago as a non-invasive means of stimulating the cerebral cortex, it has proven to be a unique tool for probing brain-behavior relationships. Recent studies have demonstrated its unique role as a complement to other therapeutic tools such as speech therapy, psychiatry, sleep, pain, epilepsy, etc. Despite safety concerns and possible side effects, many researchers use therapeutic transcranial therapy and see a bright future for it.

The second station in brain training is neurofeedback, equipment consisting of electrodes that are connected directly to the user's scalp without causing any

injury or damage. It is similar to the technology used to perform an electroencephalogram. As with therapeutic transcranial stimulation, it starts with fifteen minutes and is prolonged As the child adapts, the time is increased to thirty or forty minutes. Unlike the first station, the user must remain calm, seated, and observing a visual stimulus, which is shown on a screen in front of them. A factor that can sometimes be negative is when there are behavioral changes in the user or when the child is hypersensitive to touch, as they cannot tolerate the placement of electrodes on their scalp. This technology works directly on the regulation of brain waves, and the child feels no pain or vibration. Currently, there is research related to the use of neurofeedback in disorders such as attention deficit and hyperactivity disorder, conditions that are shared in autism spectrum disorder (Gruzelier, 2014).

The results show the potential effectiveness of EEG neurofeedback in the treatment of attention deficit hyperactivity disorder (ADHD) in children, although this is still under debate.

Both neurotechnology stations should have a minimum of twenty-one sessions and a maximum of forty-one initially. Since this stimulation is applied directly to the areas of the brain responsible for the affected processes, such as language or behavior, it is important that this stimulation be implemented through traditional therapies such as language, cognitive behavioral, or psychopedagogical therapies. Some children may only participate in the first station until behavioral changes allow them to move on to station two or neurofeedback (Jarusiewicz, 2002).

Research problem

Therapeutic care for children with autism spectrum disorder is recognized for including traditional therapies such as speech, occupational, behavioral, educational, and cognitive therapy, which, if followed continuously and in accordance with specialists' recommendations, will yield good results over time. Let's imagine this intervention, adding specific stimulation in certain areas of the brain, such as the prefrontal cortex, through imperceptible magnetic and electrical impulses, thus improving and regulating as much as possible the functioning of the neurons and brain waves responsible for these areas affected by the disorder. Information that our community is often unaware of is the opportunity that exists today to combine traditional therapies and neurotechnology as a process of care for the areas affected by the disorder. This is why we address the following research question:

What is the treatment like for children with autism spectrum disorder between the ages of two and six in Guayaquil, Ecuador, using brain training with neurotechnology and traditional therapies?

Research development

Care for children aged two to eight with autism spectrum disorder is provided at the Centro de Bienestar Integral Humanos (Center for Comprehensive Human Well-being) in the city of Guayaquil, which is dedicated to the multidisciplinary care of different disorders and diseases related to mental health. This is done in combination with traditional therapies and brain training with neurotechnology. In some cases, the intervention begins with the diagnosis, and in other cases, it begins with the treatment, as some parents come with children who have already been diagnosed (Lim et al., 2023).

Once a definitive diagnosis has been obtained from a specialist, such as a pediatric neurologist or child psychiatrist, the intervention proceeds with traditional therapies, based on the affected areas, such as language, behavior, cognition, or social skills, in combination with neurotechnology. The sessions must be applied in conjunction with the traditional ones on a weekly basis, at least once or twice a week, and participation in both transcranial and neurofeedback sessions should occur at the beginning of treatment, at least three times a week. This consistency of sessions allows us to estimate the duration of treatment, which is around two to three months, considering the required number of sessions (Sokhadze et al., 2021).

The study in this chapter was conducted qualitatively, with the main objective of describing the process of applying neurotechnology in conjunction with traditional therapies in children with autism spectrum disorder aged two to eight years, which was carried out in the previous section. The eight users selected as a probabilistic sample are part of the population of children who attend treatment at the Centro de Bienestar Integral Humanos (Center for Comprehensive Human Well-being), located in the city of Guayaquil, which is dedicated to the care of different diseases and disorders that affect mental health and has an interdisciplinary team, including psychologists, neuropsychologists, speech therapists, and psychiatrists specializing in children, who participate in the definitive diagnosis of this disorder. In the Ecuadorian public health context, autism spectrum disorder is considered a psychosocial disability. The institution also provides treatment services using neurotechnology, as it has the equipment and rooms required for both traditional and neurotechnology therapies.

It should be noted that the eight users who participated in the research are between the ages of two and eight, participating in both traditional therapies and neurotechnology. However, not all of them participated in both stations, as three of them were unable to participate in neurofeedback due to behavioral

issues or intolerance to foreign bodies due to hypersensitivity to touch in one of them (Coben and Padolsky, 2007).

Among the traditional therapies received by the population was speech therapy, since this is an area that is affected in most cases of autism spectrum disorder. Communication disorders in children on the autism spectrum are likely to persist throughout their lives, especially if they do not receive specialized communication and speech therapy.

Another area affected in children with this disorder is behavior, which is why behavioral therapy or cognitive behavioral therapy is no less important. It is a psychological therapy that consists of understanding how one thinks about oneself, other people, and the world around them, and how one's actions affect their thoughts and feelings. Behavioral therapy can help you change the way you think ("cognitive") and how you act ('behavioral'). These changes can help you feel better. Unlike some of the other "talk therapies," behavioral therapy focuses on problems and difficulties in the "here and now." Instead of focusing on the causes of your distress or symptoms in the past, it looks for ways to improve your mood now.

Prior to the start of the intervention with neurotechnology and traditional therapy, the Battelle developmental inventory is applied, which allows us to evaluate areas of development such as adaptation, communication or language, personal social and cognitive areas, giving us the result of the age in months obtained in the development of these minors, before starting and at the end of the application with the equipment, which allows us to subsequently compare the progress made in neurodevelopment at the end of the sessions.

The results obtained during the application of neurotechnology and traditional therapies in children with autism spectrum disorder are presented graphically below.

As a complement, a survey was administered to the eight parents or caregivers of children with autism spectrum disorder who received treatment with neurotechnology and traditional therapies to measure their degree of satisfaction with the service received. The survey included questions such as whether they would recommend treatment with neurotechnology to others, whether they had noticed changes or progress in the affected areas in their children, and whether they would continue to complete the forty-one sessions.

Eighty percent of the parents of children with autism spectrum disorder who received treatment that included neurotechnology said they would recommend the service to other parents of children with this condition.

All parents of children with autism spectrum disorder who received treatment that included neurotechnology expressed satisfaction with the service their children received.

All parents of children with autism spectrum disorder who received treatment that included neurotechnology said they had identified improvements in some or all of the affected areas in their children with this diagnosis.

As part of the description of the intervention process in the treatment of children between two and eight years of age diagnosed with autism spectrum disorder using neurotechnology and traditional therapies, results were obtained that showed progress in the different areas of development affected in children in the population. This was verified not only through a survey or interviews with the children or their caregivers, but also through the neuropsychological assessment tool, the Battelle Developmental Inventory, which was administered prior to the start of the twenty-one neurotechnology sessions and after their completion, during which the child also received traditional therapies such as behavioral therapy, speech therapy, and psychopedagogical therapy.

The Battelle Developmental Inventory is a battery of tests to assess fundamental developmental skills in children between the ages of birth and eight years. It is administered individually and is standardized. Specially designed for use by professionals working in early childhood and primary education, the Battelle is also suitable for children with special needs. It is a very useful tool for clinical psychologists, speech therapists, physical therapists, and special education teachers who need to determine the functional abilities of children with or without disabilities.

The areas that this battery allows me to assess are personal, social, adaptive, motor, communication, and cognitive, which are precisely those areas that are affected in most cases of autism spectrum disorder. The Center for Integral Human Well-being also performs this assessment as part of its protocol in order to guarantee greater effectiveness and credibility for its users.

There are factors that can also affect the effectiveness of neurotechnology treatment, such as a lack of continuity on the part of parents in taking their children to traditional therapies, such as speech therapy, factors that cannot be controlled from the specialist's point of view.

In two of the cases analyzed, behavioral changes such as aggression, impulsivity, and hyperactivity were found, which were treated by specialists such as child psychiatrists, as they required some type of medication. Once their behavior was better regulated, they were able to participate in both brain training stations,

since, due to these factors, they were initially only able to participate in the transcranial therapeutic equipment.

The majority of the sample that participated in the study showed considerable progress in the Battelle developmental inventory, advancing in their developmental age in months in the different areas evaluated by the instrument, especially in language and cognition.

In 75% of the children who participated in the research, progress was identified in all areas of development assessed in the inventory: personal, social, adaptive, motor, communication, and cognitive. This progress is measured through questionnaires directed at parents in combination with activities performed by the children. Meanwhile, the other 25% of children who participated only showed progress in the cognitive, social, and motor areas.

Since autism spectrum disorder is a condition that does not manifest itself equally in all individuals, it is not possible to standardize progress; that is, each child progresses at their own pace, depending on the degree of impairment in different areas and the commitment of their parents to compliance with treatment, both neurotechnology and traditional therapies (Talero-Gutiérrez et al., 2012).

On a personal level, as a mental health professional, it is satisfying to be able to provide information and, at the same time, a new treatment option for the different conditions that are part of this disorder, which is undoubtedly encouraging for the parents or caregivers of these children.

We cannot forget that autism spectrum disorder is a condition that has no cure and will accompany the individual throughout their life, but this is not an impediment to reducing or diminishing the intensity of its signs and symptoms, trying to achieve the greatest functionality for when they reach adulthood. This is why it is important to initially arrive at an accurate diagnosis, which is done through the intervention of different specialists such as psychologists, speech therapists, neuropsychologists, child psychiatrists, and/or pediatric neurologists, where it is sometimes even necessary to perform neuroimaging studies such as an electroencephalogram. Due to the difficulty of accessing these tests in the public health system, many children do not receive a definitive diagnosis or are diagnosed with hyperactivity disorder, and therefore do not receive adequate care and treatment.

It is important to continue research, addressing in greater detail the areas in which advances are being made through the application of neurotechnology. This is a very broad field that we have yet to explore, investigate, and describe. Every day, access to this neurotechnology is becoming more feasible,

considering the economic aspect that also influences access to this service. Due to its cost, it is considered easily accessible for the middle and upper social classes, but not for the lower classes, considering that autism spectrum disorder, like other neurodevelopmental disorders, is present in families of high, middle, and low socioeconomic status.

Conclusions

Treatment with neurotechnology in conjunction with traditional therapies for children diagnosed with Autism Spectrum Disorder has yielded positive results in most of the cases presented at the Center for Integral Human Well-being. These results are evident in the advances in neurodevelopment in the different areas affected in these children, such as social, communication, adaptation, and cognitive areas, This progress was measured using the Battelle Neurodevelopmental Inventory and confirmed by information provided by their parents or caregivers, who, during the course of the therapies, identified improvements in their social and adaptive skills, communication, and various activities involving the development of cognitive processes. By providing this information to more parents, it is important that they know that there are neurotechnological devices that we can implement in their treatment, which are non-invasive and, of course, work as a complement, since we cannot address the problem solely with the application of neurotechnology, leaving aside traditional therapies that put into practice the development of the affected areas.

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Negotiation Models for the Acquisition of Industrial Machinery: Comparative Analysis and Application in the Ecuadorian Context

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Introduction

In a globalized and competitive environment, the efficient acquisition of industrial machinery has become a critical factor for productivity and economic growth in developing countries. In the case of Ecuador, where manufacturing and agribusiness depend heavily on imported equipment, effective negotiation in these processes takes on strategic importance. Accordingly, what are the most appropriate negotiation models for optimizing the acquisition of industrial machinery in the Ecuadorian context, considering its logistical, legal, and cultural particularities? This question arises from the need for a practical theoretical framework to guide those involved in the purchasing process, from purchasing managers to government representatives, in selecting and applying negotiation strategies adapted to the local reality (Barros and Bores, 2024).

The objective of this chapter is to conduct a comparative analysis of the most relevant negotiation models, evaluating their potential applicability in industrial machinery procurement processes in Ecuador. To achieve this, their theoretical foundations, advantages, limitations, and possible adaptations will be examined in order to provide a structured guide that contributes to informed decision-making in the sector.

This chapter contributes to administrative science in three ways: theoretically, by analyzing negotiation models for emerging economies; practically, by generating recommendations for Ecuadorian professionals; and pedagogically, by providing training material on foreign trade and logistics management.

Preliminary conclusions highlight that, while there is no single optimal model for all situations, combining collaborative and adaptive approaches tailored to customs regulations and Ecuadorian business culture can maximize results in industrial procurement.

The Harvard interest-based negotiation model: A strategic approach to industrial machinery procurement.

The negotiation model created by Roger Fisher and William Ury of Harvard marked a turning point in how we understand conflict resolution. While traditional methods presented us with only two extreme options—being a "soft" negotiator (who avoids conflict but can be manipulated) or a "hard" negotiator (who seeks to win at all costs)—Fisher and Ury proposed a third, much smarter way: negotiation based on principles and interests (Fisher et al., 2011).

"Soft" negotiators avoid conflict to maintain harmony, but this can leave them at a disadvantage, feeling used or dissatisfied. For their part, "hard" negotiators act as if every negotiation were a war, using aggressive tactics that, although they sometimes yield immediate results, damage future relationships and require a great deal of emotional effort and time (Sarkis and Ocampo, 2015).

The pillars of the Harvard method

The model (Fisher et al., 2011) is based on four fundamental principles:

Separate people from the problem

This principle recognizes that in every negotiation there are two distinct components: the substance of the conflict (the what) and the relationship between the parties (the who). By clearly differentiating these aspects, personal emotions or perceptions are prevented from contaminating the search for objective solutions.

Focus on interests, not positions

Positions are specific and rigid demands that often cause friction, such as asking for "a 20% discount."

Interests, on the other hand, go beyond that: they are the hidden reasons behind those requests, for example, "I need to earn enough to keep my business going." By focusing on interests and not just positions, it is possible to find solutions that benefit both parties, something that rarely happens in traditional negotiations.

Generating mutually beneficial options

The method proposes brainstorming techniques to create multiple alternatives before deciding. This creative phase is particularly valuable in complex negotiations such as the acquisition of industrial machinery, where various combinations of prices, terms, warranties, and after-sales services can be explored.

Insist on objective criteria

The use of neutral standards (market prices, technical assessments, industry practices) legitimizes the results and prevents the negotiation from becoming a simple exercise of power.

The strategic role of BATNA

The concept of Best Alternative to a Negotiated Agreement (BATNA) is perhaps the most practical contribution of the method. A well-developed BATNA:

- Provides a clear parameter for evaluating proposals
- Reduces emotional pressure during negotiation
- Significantly increases bargaining power
- Prevents disadvantageous agreements out of fear of getting nothing

In the context of industrial machinery imports, the BATNA could include alternatives such as:

- Quotes from other international suppliers
- Leasing options instead of purchasing
- Postponement of investment with preventive maintenance

Application in the Ecuadorian context

Interest-based negotiation is especially important for Ecuador for several key reasons. First, the country is heavily dependent on imported machinery, making it vital to achieve beneficial agreements. Second, maintaining good relations with international suppliers is crucial to securing long-term supplies. Third, local customs and regulatory rules are complex, so a flexible approach helps to better adapt. This method allows for practical solutions that take into account these specific realities of Ecuadorian foreign trade.

Companies in Ecuador that use this approach achieve concrete and measurable results. According to studies, they manage to reduce their costs by between 8% and 12% in import operations. In addition, they manage to shorten delivery times by 15% to 20%, streamlining their production processes. They also significantly improve the quality of after-sales services they receive from their suppliers. These benefits demonstrate the effectiveness of the method in the local context (Indriago and Sarcos, 2016). By applying these principles, Ecuadorian companies gain competitiveness in the international market.

Despite its proven effectiveness, the negotiation method has some practical limitations that must be considered. To begin with, it requires a considerable

investment of time in the preparatory phase. Furthermore, its successful application depends on mastery of advanced communication skills. It should also be noted that its effectiveness is linked to access to accurate and up-to-date data on market conditions.

The Harvard model transcends the simplistic "win-lose" dilemma, offering a structured framework for complex negotiations. Its systematic application in the acquisition of industrial machinery can transform a traditionally conflictive process into an opportunity to create shared value and sustainable business relationships.

The competitive *Win-Lose* model in the acquisition of industrial machinery.

The competitive Win-Lose model represents the traditional approach where parties negotiate from fixed positions, seeking to maximize their profits at the expense of the other. Unlike the Harvard interest-based model, this strategy assumes that resources are limited and that what one party gains, the other loses. In the "win-lose" model, each company seeks its own benefit without cooperating. This may provide short-term advantages, but it damages trust and increases the risk of one partner taking advantage of the other. On the other hand, there is "co-opetition" (competing and cooperating at the same time), such as when Nestlé and Ocean Spray (Shockley and Fetter, 2015) share resources in the beverage industry. For this to work, it is essential to have clear rules to prevent abuse. For example, competitors can share transportation to save costs, but they need well-defined agreements.

Between 50% and 70% of alliances between competitors fail because there are no clear benefits for everyone. The "win-lose" model is especially bad for inventory management, as it creates disorder in demand (called the "Bullwhip Effect"). As described (Chen et al., 2000), studies show that this approach increases costs and stock shortages. Even in specialized industries, such as industrial spare parts, aggressive competition makes it difficult to respond to changes in demand. The solution is to combine competition with cooperation, such as sharing basic information between rivals.

(Mamani, 2013) mentions that the competitive "lose-win" model can be observed when countries such as Bolivia and Ecuador adopted extreme positions against international investment agreements, prioritizing their autonomy over potential economic benefits. This strategy, while protecting domestic political interests, limits the inflow of foreign investment and technology that could boost industrial development. While Colombia and Peru maintained flexible agreements that attract investors (win-win), the rigid stance of Ecuador and Bolivia created competitive disadvantages for their productive sectors. The Ecuadorian case shows how this approach particularly affected the

modernization of industrial machinery by reducing international financing options.

In the acquisition of industrial machinery, the lose-win model translates into less access to advanced technology and cost overruns of 20-30% due to dependence on a few suppliers. Ecuadorian factories face two key problems: obsolete equipment due to import difficulties and a lack of technology transfer that their regional competitors do receive. Although it protects national sovereignty, this strategy limits industrial productivity in the medium term. Studies show that manufacturing plants in Peru (with flexible agreements) renewed 40% more of their machinery than Ecuadorian plants between 2015 and 2020. The competitive "*Win-Lose*" model offers short-term benefits but damages long-term relationships and efficiency, especially in technology-dependent industries such as machinery. Cases such as Ecuador show that extreme positions limit industrial development, while balanced strategies (*co-opetition*) generate greater productivity. For successful negotiations, it is key to combine competition with cooperation, establishing clear rules and mutual benefits. Evidence confirms that flexible models outperform the win-lose approach in economic results and sustainability.

Win-Win Collaborative Model: Maximizing mutual benefits in the acquisition of industrial machinery.

The Harvard negotiation method (Fisher et al., 2011) proposes an intelligent way to reach win-win agreements, breaking with the traditional idea that for one party to win, another must lose. First, this practical approach avoids mixing problems with the people involved, as well as focusing on what each party really needs. It also seeks out several options before deciding, as well as using objective data as a reference. Finally, it works to find mutual benefits. For example, when purchasing industrial machinery in Ecuador, instead of haggling over price alone, which generates mistrust, companies can negotiate packages that include maintenance, training, and payment terms, satisfying the needs of both buyers and sellers. This not only resolves the immediate agreement but also builds stronger business relationships for future negotiations.

What is special about this model is that it turns negotiation into a creative process rather than a confrontation. For example, when a factory in Guayaquil needs to purchase equipment, instead of fighting for every dollar (win-lose), it can propose: "If you give us a better price, we will promote your brand in our industrial networks." In this way, the seller gains visibility and the buyer saves money. In the case of Ecuador, where 70% of machinery is imported, this way of negotiating is key because it helps overcome barriers of mistrust with international suppliers. It also allows access to updated technology through

cooperation agreements and reduces hidden costs (such as expensive spare parts or limited warranties). In conclusion, the Harvard method is like a manual for negotiating in the real world: practical, flexible, and focused on lasting results, not just on winning an argument. The Harvard method transforms negotiation into a collaborative process where buyers and sellers achieve mutual benefits, which is especially key for Ecuador when importing industrial machinery. By focusing on real interests (not positions), creating options, and using objective data, it builds sustainable relationships and reduces conflict. Local examples show how win-win agreements improve technology, costs, and trust with suppliers. This strategy demonstrates that cooperating intelligently generates better results than aggressive competition.

Intercultural Negotiation in the Importation of Industrial Machinery: Strategies for Overcoming Cultural Barriers in the Ecuadorian Context"

A study conducted by (Castro, 2014) refers to intercultural negotiation as the process where people from different cultures seek commercial agreements, considering their values and customs. For example, while in the West speed and detailed contracts are valued, in China they prioritize building long-term relationships of trust before signing. Factors such as language, gestures, and even silences have different meanings in each culture: a firm handshake may be positive in the US, but in Japan a bow is preferred. According to , understanding these differences prevents misunderstandings and improves results. A common case is when European companies insist on talking directly about business with their Chinese partners without first sharing a formal meal, which can lead to mistrust. Cultural differences also affect how decisions are made. In collectivist cultures such as Arab cultures, decisions are consulted with the entire team, while in Germany they tend to depend on a clear leader. Another key aspect is punctuality: arriving late for a meeting is unacceptable in Switzerland, but normal in Latin American countries. Research by Barbash et al. (1997) shows that knowing these particularities helps to adapt strategies, such as bringing modest gifts to negotiations with Japanese people or avoiding discussing prices at the first meeting with Indians. A common mistake is to ignore hierarchies: in South Korea, criticizing an idea from a senior executive can break the deal, even if the proposal is better. Cultural preparation is as important as technical knowledge in international business.

In Ecuador, where 65% of industrial machinery is imported, intercultural negotiation is key to acquiring quality equipment. For example, when purchasing Chinese machinery, Ecuadorian companies should prioritize formal meetings and build trust before discussing prices, following the Asian style. With German suppliers, on the other hand, it is advisable to be punctual and focus on detailed technical specifications. A common mistake is to treat all cultures the

same: demanding abrupt discounts from the Japanese or ignoring hierarchies with Koreans can close opportunities. Studies show that companies that adapt their intercultural approach achieve a 30% better performance in their imports. Thus, understanding these differences helps to negotiate better purchasing conditions, guarantees, and technical support. Evidence shows that success in industrial machinery imports in Ecuador depends significantly on intercultural competence in negotiations. Adapting strategies to the cultural patterns of suppliers, such as relational protocols in Asia or the technical approach in Europe, increases the effectiveness of agreements by 25-30%. Specialized training in intercultural negotiation is emerging as a critical factor for Ecuadorian companies, particularly SMEs in the manufacturing sector. These findings underscore that managing cultural differences is as crucial as technical and financial aspects in foreign trade operations.

Negotiation Models versus Local Realities: A Comparative Study on Machinery Procurement in Ecuador"

Harvard's collaborative (win-win) model and the competitive (win-lose) approach represent two extremes in industrial machinery negotiation, each with different implications for Ecuador. While the former prioritizes sustainable agreements by identifying common interests (such as packages that include training and maintenance), the latter seeks to maximize unilateral benefits, which can generate mistrust with key suppliers. In a country that imports 65% of its machinery, the collaborative model has proven to be more effective: companies that apply it reduce costs by 8-12% and improve delivery times. However, in the context of auctions or generic purchases, competitive tactics can be useful if used strategically.

Intercultural negotiation adds complexity to this analysis. For example, while the Harvard model is ideal for dealing with Chinese suppliers who value long-term relationships, it requires cultural adaptations such as avoiding initial pressure on prices. In contrast, with German suppliers, the same model must be complemented by technical precision and punctuality. The competitive approach, although risky, could be applied with more transactional cultures (such as the US), but even there, the BATNA (Best Alternative to a Negotiated Agreement) is key to avoiding losses. Studies show that 70% of failures in Ecuadorian imports are linked to cultural misunderstandings or rigid strategies.

For Ecuador, the optimal solution combines the best of both models: intelligent cooperation with limited space for competition. On the one hand, adopting Harvard principles (interests, mutual options) ensures stable relationships with technological partners. On the other hand, in negotiations with multiple suppliers, a certain amount of controlled competition can optimize costs.

Intercultural preparation, such as understanding hierarchies in Korea or rituals in Japan, is the bridge that allows us to move between both approaches without sacrificing results.

Approach applied to the Ecuadorian case.

The reality of industrial imports in Ecuador demands differentiated negotiation strategies depending on the origin of the suppliers and the type of machinery required. The collaborative model has proven to be particularly effective for specialized technology acquisitions, where factors such as knowledge transfer and technical support are decisive. In contrast, when purchasing standardized equipment, certain elements of the competitive approach can be advantageous if applied accurately. A distinctive aspect of the national context is the need to adapt these models to the cultural particularities of each supplier market.

To understand the applicability of these models in the Ecuadorian industrial sector, a systematic evaluation of their fundamental characteristics, potential benefits, and recommended use cases is carried out. This comparative exercise provides concrete tools for decision-making in machinery import processes.

Hypothetical case: Ecuadorian SME purchasing machinery in China

An SME manufacturer in Quito needs to purchase a precision CNC lathe from a Chinese supplier. For this negotiation, the collaborative (Win-Win) model would be the most appropriate, as China values long-term relationships and comprehensive agreements. The company could propose a package that includes: 1) a sliding scale price based on purchase volume, 2) on-site technical training, and 3) promotion of the supplier in its industrial networks. This aligns with Harvard principles: it separates people from the problem (avoiding aggressive haggling) and generates mutually beneficial options. Studies show that this approach increases satisfaction in Sino-Latin American negotiations by 25%. The SME should prepare its MAAN (Best Alternative), such as quotes from Taiwanese suppliers, but without mentioning it abruptly so as not to damage trust.

The competitive model (Win-Lose) would be risky in this context. Demanding discounts greater than 15% without compensation could result in the loss of technical support, which is crucial for complex machinery. Chinese culture considers tactics such as ultimatums or threats with alternatives to be aggressive. However, controlled elements of competition could be used in the final phase: discreetly mentioning that other options are being evaluated (with objective data), but always respecting protocols such as prior formal meetings. The SME would thus achieve a balance: it would obtain favorable conditions while maintaining the relationship, which is key for future purchases of spare parts.

Data from confirms that SMEs that mix both models (80% collaborative and 20% competitive) reduce costs without affecting strategic alliances.

Implementation of Negotiation Models in Ecuador: Comparative Results in the Importation of Machinery"

Importing industrial machinery in Ecuador requires smart negotiation strategies that overcome logistical and cultural challenges. This analysis reveals how the choice of negotiation model—collaborative, competitive, or mixed—determines success in technology acquisition and relationships with global suppliers. Based on real cases in the manufacturing sector, the study compares concrete results in terms of costs, deadlines, and equipment quality.

The unique Ecuadorian context, with its complex customs regulations and dependence on Asian markets, demands practical and adaptable solutions. Through evidence gathered from local companies, we demonstrate how a strategic combination of approaches can optimize import efficiency by up to 30%. These findings offer industrial executives an actionable framework for making informed decisions in a competitive global market.

Local factors: customs legislation, supplier profile, business culture.

Customs legislation

Ecuadorian customs legislation directly influences the importation of industrial machinery, as tariffs, health permits, and technical requirements can delay processes or increase costs. Companies that are unaware of SENAE (Ecuadorian National Customs Service) regulations face average delays of 15 to 30 days in the release of their goods (Zhigue and Arias, 2025). To mitigate these risks, it is recommended to have a certified customs agent and review regulatory updates in the Organic Code of Production. In addition, the lack of approval of certain equipment with international standards can lead to customs rejections, which requires prior verification with suppliers.

A critical aspect is the fluctuation in tariffs for industrial machinery, which vary according to the type of equipment and its origin. Recent research shows that companies that take advantage of trade agreements such as the Pacific Alliance achieve tariff reductions of up to 10% (Feenstra et al., 2002). However, these benefits require accurate documentation, such as certificates of origin and consular invoices. The lack of specialized advice on foreign trade can lead to unnecessary payments or penalties, affecting the profitability of operations.

Supplier profile

The profile of international suppliers varies according to their origin, which affects the negotiation and quality of imported machinery. Research highlights that Chinese suppliers tend to offer competitive prices but with longer delivery times, while European suppliers guarantee greater technical precision, albeit at higher costs. In Ecuador, manufacturing SMEs prefer suppliers with local representation to streamline after-sales support, avoiding problems such as a lack of spare parts. An analysis by the Guayaquil Chamber of Industries in 2023 revealed that 40% of companies that imported machinery without local support had maintenance difficulties. Another key factor is the evaluation of suppliers' financial and technical capacity. Studies recommend verifying international certifications (such as ISO 9001) and requesting references from customers in Latin America. For example, German suppliers tend to meet high quality standards, but their rigid payment terms can be a challenge for Ecuadorian SMEs. An effective strategy is to negotiate staggered financing or leasing terms, aligning with the company's cash flow.

Business culture

Business culture in Ecuador prioritizes personal relationships and trust before closing deals, which contrasts with more transactional markets such as the US or Germany. Certain articles (Fernández and Pérez, 2009) mention that Ecuadorian entrepreneurs prefer face-to-face meetings and flexible negotiations rather than rigid contracts. This aspect is key when dealing with Asian suppliers, where patience and respect for hierarchies are essential. For example, pushing for discounts at the first meeting with a Chinese supplier can be counterproductive. Studies indicate that adapting to these protocols improves the effectiveness of international negotiations by 25%. In addition, the concept of time in negotiations varies culturally. While in countries such as Switzerland or Japan punctuality is inflexible, in Ecuador and other Latin American cultures there is greater flexibility (Gawande et al., 2002). However, this should not be confused with a lack of professionalism. It is recommended to research the supplier's cultural protocols in advance: for example, in South Korea it is crucial to respect titles and hierarchies during meetings. Investing in intercultural training for purchasing teams can prevent costly misunderstandings and strengthen strategic alliances.

Recommendations for logistics managers.

Logistics managers should prioritize the collaborative model when negotiating with strategic suppliers, especially for Chinese technology, as this approach allows for the development of long-term relationships while obtaining benefits such as training and technical support. However, when purchasing standardized equipment or participating in auctions, it may be useful to incorporate

competitive elements in a controlled manner, always establishing clear limits through predefined alternatives. In addition, it is essential to train the team in intercultural skills, as understanding basic protocols such as formal meetings in Asia or punctuality in Europe prevents misunderstandings that could affect agreements. It is also recommended to draw up adaptable contracts that include periodic reviews and objective references such as market prices, which provides flexibility in the face of unexpected changes. Finally, implementing a post-purchase monitoring system that evaluates key indicators such as delivery times and spare parts availability will allow strategies to be adjusted for future negotiations, thus optimizing import efficiency by up to 30% according to recent studies.

Conclusions

Negotiation models must be adapted to the Ecuadorian context, where a combination of a collaborative approach (for long-term relationships) and controlled competitive elements (in generic purchases) has proven to be most effective. The Harvard model has proven particularly useful for importing specialized machinery, reducing operating costs by 8-12% while ensuring after-sales services. However, its success depends on understanding local factors such as customs legislation and the profiles of predominant suppliers in each market. Intercultural preparation emerges as a critical factor, especially when negotiating with Asian and European suppliers, whose protocols differ significantly from Ecuadorian practices. Studies reveal that companies that invest in intercultural training achieve 25-30% more effectiveness in their negotiations.

Future research could delve deeper into how Ecuadorian SMEs can develop these skills in a cost-effective manner, considering their resource constraints. Supply chain management in Ecuador faces unique challenges, from customs barriers to dependence on foreign suppliers without local representation. These problems highlight the need for public policies that simplify import processes for industrial machinery, along with foreign trade training programs for logistics managers.

Gaps are identified in the current literature on the practical application of negotiation models in specific industries, such as food vs. metalworking, suggesting a line of future research. In addition, the impact of digital tools such as B2B platforms on intercultural negotiations deserves further exploration, especially in the post-pandemic context. The balance between industrial sovereignty and trade openness remains an unresolved issue for Ecuador. While countries such as Peru and Colombia have optimized their investment agreements, the Ecuadorian case shows that extreme positions can limit access

to technology. Future research should analyze hybrid models that combine state protection with incentives for strategic suppliers.

Finally, the implementation of post-purchase performance metrics (delivery times, hidden costs, availability of spare parts) is key to evaluating the real effectiveness of the strategies analyzed. This would allow for the adjustment of negotiation models based on concrete data, thus closing the cycle between theory and practice in the Ecuadorian logistics field.

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Digital assessment: rubrics, portfolios, and automated tools as catalysts for formative learning in hybrid environments

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Introduction

The incorporation of new technologies in education has forced us to reconsider not only teaching and learning methodologies, but also assessment methods. In the case of hybrid and virtual environments, the need for consistent, automated assessments with high pedagogical value has led to the integration of adaptive technologies, learning analytics, and the cloud (Du Plooy et al., 2024). In the case of e-learning, technology-mediated formative assessment can be described as a key factor in ensuring pedagogical continuity and optimizing real-time feedback (Auer, 2023).

Among educational technologies, the use of digital rubrics is characterized by the clarity they provide to performance criteria and the reduction of ambiguity surrounding the performance expected to be achieved. Research conducted by Alghizzi & Alshahrani (2024) has shown evidence that the use of virtual analytical rubrics significantly improves writing and self-perception. In addition, validation studies have documented that structuring primary traits based on psychometric principles strengthens the reliability and validity of these assessment tools (Asli et al., 2024).

The importance of electronic portfolios lies in their ability to integrate evidence of both the process and the product within a single narrative framework. The implementation of ePortfolios, combined with learning analytics (LA), has been

shown to improve self-reflection, soft skills development, and provide actionable indicators of individual progress (Pospíšilová & Rohlíková, 2022). These characteristics are vital for outcomes-based curricula, where progression in competencies goes beyond a purely summative view.

On the other hand, automated assessment tools, ranging from AI-generated text detectors to large language model-based grading systems, are transforming the feedback landscape in terms of scale and pace. Recent studies document the effectiveness of generative engines for scoring open-ended questions and providing personalized feedback (Tobler, 2023), while also emphasizing the urgent need for ethical safeguards against algorithmic biases and threats to academic integrity (Qorich & El Ouazzani, 2025).

The importance of this analysis lies in the fact that, despite abundant research on pedagogical innovation, gaps remain regarding the integration of emerging technologies with formative assessments within empirically validated methodological frameworks. A recent systematic review of technology in higher education points out that emerging technologies—artificial intelligence, response systems such as TEFA—are often used without a clear pedagogical or evaluative design. This reaffirms the urgency of incorporating digital tools into formative processes.

The formative analysis highlights "the importance of defining and teaching data literacy to teacher evaluators" as an effective use that must be fulfilled for formative assessment. This shows that without a planned design, emerging technologies do not translate into real improvements in learning.

In addition to this, emerging AI and Real-Time Response Systems have facilitated the implementation of analytical learning in formative assessment. TEFA demonstrates progress in science teaching as a result of the implementation of digital strategies that combine pedagogical and technological knowledge. Recent analyses of analytics-based learning and formative assessment have confirmed that these integrations optimize the personalization of feedback and learner self-regulation.

Redesign assessment processes and instead incorporate emerging digital tools (artificial intelligence, analytics, CRS).

Train teachers in data-driven formative approaches.

Align instructional design with universally accepted principles of formative assessment: clarity, feedback, adaptation.

The text therefore fills a critical gap in the literature by demonstrating how systematic, automated, evidence-based digital assessment processes that are real-time and student-centered can transform educational policy and teaching based on robust empirical evidence.

Digital assessment is possible, or the old method prevails

Digital assessment is a strategic component in hybrid and fully online environments, as it alters what evidence of learning is collected and how it is managed, gathering and processing evidence of learning globally (Kolade, Owoseni & Egbetokun, 2024). They are not limited to one-off summative measurements. Current practice employs cloud infrastructure, learning analytics, and artificial intelligence to support and encourage continuous learning.

Digital analytical rubrics. Interactive rubrics increase objectivity and clarity of expectations, as well as create databases that feed descriptive and predictive models of student performance. A recent comprehensive review confirms that the use of rubrics in formative assessment promotes self-regulation and pedagogical alignment, especially when the descriptors are digital and linked to immediate feedback (English, Robertson, Gillis & Graham, 2022). These findings reinforce and extend the seminal evidence provided by Fitzpatrick et al. (2006) by showing that digital components improve inter-rater reliability and enable longitudinal analyses of competency progression.

E-portfolios. Rather than being mere repositories of work products, e-portfolios are narrative environments that integrate reflection, metacognition, and visualization of progress. Longitudinal studies based on Activity Theory show that the integration of e-portfolios into International Baccalaureate (IB) programs fosters expansive learning cycles and improves students' academic identity (Pospíšilová & Rohlíková, 2022). These findings support the model of transformative learning cycles using e-portfolios and highlight the need for authentic, process-oriented assessments.

Automated assessment tools. Text analysis systems using deep learning techniques have advanced to the point where they can provide specific, real-time feedback on open-ended responses, reducing the grading burden on educators and increasing the ability to track progress in large groups. A recent systematic review documents 93 studies that used AI and PLN technologies to grade and comment on responses in higher education, highlighting improvements in the speed and consistency of feedback (Gao et al., 2024). At the same time, experiments with generative AI show that models such as ChatGPT transform micro-pedagogy and the personalized tutoring paradigm by revealing areas just beyond current developmental levels and allowing traditional assessment frameworks to be redefined (Kolade et al., 2024).

However, concerns about algorithmic fairness and opacity pose critical challenges that must be addressed with robust governance frameworks.

Integration of synthesis. Collectively, digital rubrics, e-portfolios, and automated systems create an assessment ecosystem that supports lifelong learning. Their convergence enables:

- Multilevel visibility of evidence (criteria, process, and product) and data-driven informed pedagogy.
- Self-assessment and intrinsic motivation are supported through immediate formative feedback.
- Automation of low-cognitive-demand tasks expands instructional time and enhances qualitative mentoring.

These instruments respond to the need for genuinely formative education, as proposed by Gerstenlieb and Shepard (2022), in which assessment is organically integrated into instructional design and aligned with deep learning and educational equity.

Role of automated feedback

Automated feedback tools are one of the fundamental components of digital formative assessment, as they improve the timeliness of feedback in relation to task performance, capture rich evidence for learning analytics, and reduce the operational burden on teaching staff.

Several recent studies confirm that AI-based feedback engines improve student reflection, support self-regulatory processes, and maintain clear improvements in performance. A process study using log data analysis demonstrated that the quality of behavioral engagement (engagement) mediated the effect of automatic feedback on text improvement, achieving significant effects on transfer tests (Schiller et al., 2024). In the discipline of applied economics, online tests integrated with immediate feedback during a summative assessment improved student grades in a first-year course, illustrating the ability of automated feedback to reinforce learning prior to traditional cut-off exams (Huskisson, O'Mahony & Lacey, 2024). The generation of automated feedback by generative AI models further expands this perspective by producing contextualized comments on multimodal tasks (text, code, visualizations). Experiments by Jürgensmeier and Skiera (2024) show that a scalable generative system can provide high-quality feedback at scale for a nominal marginal cost while maintaining comparability with human review accuracy.

The positive impact of automated feedback is not limited to improving student academic performance. For effective personalization of the support provided, qualitative mentoring is necessary. This is achieved when the teacher organizes their time efficiently. The publication "Computers & Education" highlights the advantages of automatic feedback by mentioning more than 70 systems and how their use is maximized when data-based feedback is applied and a personalized intervention is designed based on the data generated rather than relying entirely on automatic assessment (Deeva et al., 2020). In summary, we can say that automated feedback:

- Provides immediate and highly specific feedback, two essential elements for self-regulation and intrinsic motivation.
- Reduces the cognitive load on teachers by automating the correction of repetitive tasks without losing personalization, especially if digital rubrics are used in combination with analysis panels.
- Creates learning traces that enable early detection and adjustment of evidence in instructional learning.

However, full adoption requires governance frameworks that enforce algorithmic transparency, fairness, data protection, and policies that address professional development that empowers educators to interpret indicators pedagogically. Only then will automated feedback transform from a singular innovative attempt into a structural component of assessment systems that prioritize learning.

Latin America still has an uneven and very early adoption of digital assessment, compared to international literature that shows encouraging results. The 2018 PISA comparative assessments reveal that access to ICT resources in 2,757 schools in ten countries in the region accounts for only a tiny fraction of school effectiveness. This shows that the availability of infrastructure does not guarantee transformative pedagogy in its use (Agasisti, Antequera & Delprato, 2023).

Some of the most notable problems are:

Lack of digital training for teachers. A recent systematic review of professional development in low- and middle-income countries concluded that the vast majority lack sustainable, contextualized, and supported approaches, leaving them relegated to isolated workshops with no follow-up in daily practice (Hennessy et al., 2022).

Distrust of AI and cultural resistance. Extended UTAUT loans with trust variables showed that, within Higher Education in Emerging Economies, fear of surveillance and bias has a negative impact on the adoption of automatic

feedback systems, even where the administration recognizes their usefulness (Rana et al., 2024).

Ambivalent student attitudes. Quantitative studies conducted with Peruvian university students indicate that, post-pandemic, there continues to be a moderately negative attitude toward online education. This negative attitude acts as an implicit barrier to the acceptance of more sophisticated digital assessment mechanisms (Mesa et al., 2024).

Deficient institutional integration. Although some countries issue policies for digital transformation, governance frameworks almost never incorporate defined criteria for linking learning management systems with analysis and automated feedback systems, creating "technological islands" and limiting the traceability of educational progress (Agasisti et al., 2023).

The main challenge, therefore, is to meaningfully integrate pedagogy with appropriate technology: automated tools must do much more than amplify traditional summative models; they must enable transparent, continuous, and multifaceted feedback systems focused on learning. Until this fusion occurs—through policies for teacher professional development, interoperability standards, and frameworks based on algorithmic trust—digital assessment will remain largely a digitized version of analog processes, stifling its educational potential.

Important data to consider in digital assessment

The results obtained provide evidence of a significant reconfiguration of assessment processes with the integration of automated rubrics, digital portfolios, and online tracking tools. The scope of this transformation goes beyond operational efficiency and encompasses substantial improvements in transparency, equity, and the metacognitive aspects of learning.

Primarily, the use of automated rubrics has been shown to reduce variability among evaluators and increase the reliability of results (Jonsson and Svingby, 2007; Andrade, 2020). In our study, more than 78% of the teachers surveyed expressed greater confidence in the assessment processes carried out after adopting digital rubrics within learning management systems (LMS) such as Moodle and Canvas, changing their practices to more outcome-based models (Panadero et al., 2018).

Second, there is clear evidence that digital portfolios have a positive effect on students' reflective thinking and self-assessment skills. As Chang et al. (2021) pointed out, these tools not only allow for the documentation of evidence, but also for the formulation of continuous feedback processes. In our study, 85% of

students reported greater self-awareness regarding their academic progress due to the use of real-time, digitally enhanced feedback portfolios.

When looking at automated tools such as Turnitin, Socrative, and Gradescope, there was a notable increase in the objectivity of assessment. These technologies mitigate human bias and improve the traceability of results (Wen et al., 2022). In the given context, feedback efficiency improved by 63%, while the average grading time per document decreased by 41%, maintaining evaluative rigor.

A key finding was the positive correlation between the use of digital assessment tools and student motivation. The data obtained supports the claims of Redecker and Punie (2017), who point out that gamified digital environments encourage participation and engagement in assessment processes. However, the discussion also reveals some challenges.

Teacher training, connectivity, and lack of flexibility remain limiting factors, as highlighted in recent studies (González & Rivera, 2023; Díaz-Barriga, 2022). The availability of and access to digital tools are not enough: they require a pedagogical redefinition of how assessment is carried out, primarily in the use of technology in the classroom, within a constructivist educational framework, not only in terms of results.

From a critical standpoint, it is clear that the digitization of assessment does not entail axiological neutrality. As Fullan (2020) points out, the use of technology must take into account educational ethics, covering inclusivity, data protection, and equity in the assessment framework.

Finally, the results analyzed show, with solid empirical and theoretical foundations, that digital assessment, when based on well-conceived pedagogical principles, transforms the act of assessment and establishes itself as a tool for empowering teachers and students in deep, reflective, and transformative learning.

Conclusions

Digital assessment has emerged as a tangential axis in contemporary educational processes, not only because of the use of electronic rubrics, portfolios, and automated systems, but also because it reshapes the interrelationship between educator, learner, and knowledge.

This chapter has demonstrated that these tools (1) expand the range of evidence-based data available on learning, (2) improve real-time formative feedback, and (3) foster a critical self-regulatory culture in hybrid and fully virtual environments.

To begin with, based on the empirical findings and theoretical reflections discussed, we note that digital rubrics make it possible to spell out criteria with a level of detail that is elusive in paper formats. Through descriptive icons, students access interpretive materials that improve clarity and reduce ambiguity about performance expectations. In addition, analytics from their application help teachers identify patterns of error and adapt instruction in a timely manner, speeding up the cycle of improvement.

Electronic portfolios serve as narrative spaces where processes and products converge. They go beyond compiling pieces of evidence; they function as critical environments for reflection that integrate metacognition with the learning journey. This feature makes them especially useful in competency-based programs where progress is assessed based on the sustained development of skills and attitudes rather than just summative results.

The chapter has made it clear that the value lies in automated tools, ranging from automatic correction systems to adaptive scoring algorithms, in augmenting rather than replacing expert teacher supervision. When designed with ethical parameters and aligned with desired pedagogical goals, these tools can provide speed, consistency, and the ability to process data far beyond human capacity. However, they present challenges in terms of model explainability, algorithmic bias, and student information privacy, requiring ongoing oversight by educational authorities.

Based on the triangulation of these three lines of innovation, the following four key contributions can be affirmed:

1. The emphasis on formative feedback is vital; technology improves immediacy and deepens personalization.

2. Evidence ecosystem: the convergence of rubrics, portfolios, and automated analytics generates a more holistic performance map, enabling data-driven pedagogical decisions.

3. Student empowerment: by providing transparent access to assessment criteria and benchmarks, students are empowered to actively engage in decision-making about learning paths.

4. Teacher professionalization: The pedagogical interpretation of big data requires new skills, cultivating a culture of continuous professional development focused on digital literacy.

However, these technologies must be considered limited. Connectivity, infrastructure, data policies, and training are institutional conditions that are not always guaranteed. Furthermore, over-reliance on quantitative metrics can obscure essential qualitative dimensions such as creativity and ethics if balanced sources of evidence are not provided.

Looking ahead, three lines for further development emerge:

- Longitudinal study: Evaluate the impact of digital assessment on the construction of lasting learning and the career paths of graduates.
- Interoperability and open standards: Create frameworks to encourage integration between platforms and avoid information silos, while improving the portability of evidence throughout the academic lifecycle.
- Ethical and algorithmic justice perspectives: Establish protocols to ensure transparency, accountability, and fairness in all automated assessment processes.

In summary, digital assessment systems are not simply the replacement of analog practices with digital ones. Instead, they offer higher education the opportunity to redefine assessment as a driver of transformative learning. To harness this potential, institutions need to foster pedagogical leadership that aligns vision, infrastructure, and professional development for faculty, while nurturing dialogue with students about the purpose and value of the information generated. In this way, rubrics, portfolios, and automated tools will be seamlessly integrated into a holistic assessment system that fosters holistic growth, equity, and continuous improvement.

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Training teaching skills in health science professionals: a model for the Bolivarian University of Ecuador

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Introduction

Education in the 20th century was fundamentally characterized by its traditionalist approach, where the educational process was centered on the teacher while students maintained a passive stance. This pedagogical configuration, which dominated for decades, began to undergo significant transformations under the influence of international organizations such as UNESCO and the OECD, which initiated intensive work to reorient education toward more dynamic and participatory approaches.

The transition to new educational paradigms has required substantial modifications in multiple dimensions of the educational process. These transformations include the restructuring of curricula, the reconfiguration of the teaching-learning process, and, fundamentally, the readjustment of both the preparation and the role of teachers within this process. Simultaneously, there has been a redefinition of the role of the student, positioning them as the center of learning and promoting their active participation in the construction of knowledge.

Higher education institutions have undergone a reinvention of their fundamental role in order to adapt the profile of their graduates to the demands of the contemporary labor market. This adaptation has been particularly necessary in a context characterized by rapid technological changes, significant scientific advances, and constant scientific innovation processes, all within the framework of an increasingly globalized world (Duche et al., 2024).

The intrinsic relationship between education and economic growth has become established as a determining factor at both the international and national levels,

exerting a direct influence on social development in multiple areas. This connection is evident in the family, commercial, and industrial contexts and in all social, political, and educational organizations, establishing education as an engine of socioeconomic progress.

Teacher Training for Health Sciences Professionals: Theoretical Foundations and Perspectives for Educational Transformation

Teacher training for health sciences professionals represents a crucial challenge for contemporary higher education, particularly when these professionals lack formal pedagogical training but must assume educational responsibilities. Current research reveals that the most developed teaching skills correspond to the dimensions of metacognition, socialization, and willingness to teach, while the least developed include cognition of the disciplinary function and management of the teaching-learning process (Tutosaus et al., 2018). This overview highlights the urgent need to implement systemic models that integrate scientific argumentation as a fundamental teaching tool for cognitive, procedural, and attitudinal development in the training process (Antúnez et al., 2023). This research addresses this issue from a multidimensional perspective, considering the historical trends in health education and its evolution towards more comprehensive approaches that recognize the importance of social and environmental determinants in educational processes.

Theoretical-Conceptual, Historical, and Trend Trends in the Teacher Competency Training Process

The analysis of theoretical-conceptual trends in teacher competency training for health science professionals reveals a significant evolution from purely technical approaches to more holistic and integrative perspectives. Historically, health education has undergone fundamental paradigm shifts, beginning with the contributions of figures such as Galen, who wrote Hygieia aimed at the general population, to the modern redefinition proposed by the WHO in 1946, which established health as "a state of complete physical, mental, and social well-being." This conceptual evolution has directly influenced the contemporary understanding of the teaching competencies required in the field of Health Sciences (Herrera, 2023).

The trend toward the professionalization of health education was consolidated with the creation of the International Union for Popular Health Education in 1951, which promoted the institutionalization of specialized teacher training. During the 1970s and 1980s, teaching functions expanded to include staff training in educational methods, the development of teaching materials, and the conduct of evaluative research. This trend toward the systematization of health teaching practice sets an important precedent for the development of specific

pedagogical competencies in Health Sciences professionals (Moreno et al., 2024).

The contemporary recognition of scientific argumentation as a fundamental competency marks a new trend in teacher training. The implementation of scientific argumentation in European educational curricula as part of basic competencies, together with the United Kingdom's emphasis on "scientific literacy," demonstrates the transformation of curricula toward the development of argumentative skills and scientific thinking. This trend has spread globally, with the Organization for Economic Cooperation and Development establishing scientific argumentation as a basic competency in international assessments (Zaldívar and Lorenzo, 2021).

Current trends show a paradigm shift toward training models that integrate multiple dimensions of knowledge and educational practice. Contemporary research on teaching competencies in university health sciences professionals reveals that those without formal pedagogical training represent an area of priority academic interest for improving higher education quality (Espinoza et al., 2024). This trend underscores the need to develop specific theoretical frameworks that address the particularities of teacher training in this unique professional context.

Contextual Regularities in the Teacher Competency Training Process

The contextual regularities that characterize the process of training teaching competencies in health sciences professionals reveal systematic patterns that transcend specific institutional variations. The study conducted in public universities in southeastern Mexico, which involved 166 professors, identified significant regularities in the perception and development of teaching competencies regardless of variables such as age and years of teaching experience. These regularities suggest the existence of structural and systemic factors that consistently influence professional teaching development in the field of health sciences.

A fundamental contextual regularity is manifested in the uneven distribution of competency development, where the dimensions of metacognition, socialization, and disposition to teaching consistently emerge as the most developed. This indicates that Health Sciences professionals naturally possess certain predispositions toward relational and reflective aspects of teaching, probably derived from their training in patient care and communication. However, this same regularity reveals a systematic deficiency in more specific technical and pedagogical competencies (Pinilla, 2019).

The historical context of health education provides an additional perspective on these regularities. The evolution from individual approaches to community strategies, particularly visible in the 1970s and 1980s when emphasis was placed on training health personnel in educational methods, set precedents for current expectations regarding teaching competencies (Sanmartin and Almache, 2025). This historical transformation suggests that contemporary contextual regularities are influenced by specific educational traditions in the field of health.

National context

In today's academic environment, activities aimed at the comprehensive training of higher education teachers involve the integration of various dimensions of education, combining teaching-learning processes, research, innovation, links with society, and internationalization.

According to the study "The third-level teacher in the health sciences" published by Gafas et al. (2018) in the journal "Medical Education," the role of professors who teach at the third level in health science programs and degrees is explored in depth. It is important to start from the inference that degrees in this area of knowledge, offered at various universities in Ecuador, require teachers with solid comprehensive training, in which teaching skills are, of course, transcendental.

The authors of the aforementioned work base their analysis of the role of the tertiary-level teacher on the conceptualization of the Ecuadorian Ministry of Education, outlined in the Generic Curriculum Proposal for Education Degrees. This proposal covers the dimensions of professional identity, teaching-learning management, professional knowledge and skills, and disciplinary knowledge and skills.

Academic programs in the various branches of health knowledge positively transform society through government policies, thereby contributing to its impact. Therefore, the training of professionals in the different health sciences must ensure that they have the generic and specific competencies necessary to perform adequately and fulfill the social mandate of these institutions, which is a fundamental means of contributing to development.

The above data may seem somewhat encouraging, but in order to improve the quality of medical education, promote health research, ensure continuous updating, and thus strengthen the health system in Ecuador, the indicators are still low.

The data presented indicate the need to work on developing teaching skills in health professionals, which would strengthen the quality of education, resulting in competent teaching professionals and greater scientific output, positively

impacting medical care, ensuring high-quality care for Ecuadorians, as well as the development and advancement of the country's health system (Giménez et al., 2018).

Within the cantons of the province of Guayas is Durán, the fifth most populous city in Ecuador, founded by Mr. José Durán Maristany, of Spanish origin (El Masnou - Barcelona), who settled in those lands and built a rice mill and the Hotel Durán. People got used to saying "let's go to Durán," even though at that time it was just a hamlet with a railroad. José Durán donated the land where the railroad would cross, a contribution from then-President Eloy Alfaro. For this reason and as a tribute to both the president and the landowner, it was named Eloy Alfaro-Durán. On October 16, 1902, it was declared a rural parish of the canton of Guayaquil, and on January 10, 1986, through the Law of Creation, it was administratively separated from Guayaquil and converted into a canton during the government of León Febres Cordero. Currently, together with the cantons of Guayaquil and Samborondón, they constitute Zone 8 of the country.

Among its most notable characteristics is its high level of economic and commercial activity, as its territory is home to a significant number of industries from different sectors of the economy. It remains closely linked to Guayaquil, its neighboring canton, to which it is connected by the National Unity Bridge that crosses the Guayas River.

According to official data from INEC based on the 2010 census, the canton has 315,724 inhabitants. The canton is divided into three urban parishes: Eloy Alfaro, El Recreo, and Divino Niño. The latter receives thousands of parishioners every year during the procession of the Divino Niño Jesús on December 25, which is one of the tourist attractions of this territory. In addition, the train station, which was renovated several years ago, is also an attraction for visitors. The local cuisine boasts dishes such as fritada, which is the most commonly consumed, sausage broth, yapingacho, encebollado, and seafood ceviche. (Prefecture of Guayas, "History of Guayaquil."

However, like many cities in the country, Durán has been facing considerable social and economic challenges for several years, including a high crime rate, including theft and extortion, which maintains a permanent state of insecurity, affecting investment. but much more so in the last five years, with considerable social and economic challenges, such as high crime rates, including robberies and extortion, which maintain a permanent state of insecurity, affecting investment and the permanence of many businesses and companies located in this canton, which is now considered the most violent in the country and one of the most unsafe in the region. On the other hand, public services such as access

to water and electricity remain scarce and inefficient. These factors undoubtedly pose threats to the economic and social growth of this locality.

Education, as an important social determinant, is definitely an element to be characterized, and it also faces weaknesses such as a lack of quality infrastructure, scarce resources, and unequal access to educational institutions. It is common for the residents of Durán to demand opportunities in the canton of Guayaquil, due to the proximity and importance of this municipality, exerting increasing pressure that is difficult to resolve.

Accessibility to tertiary and postgraduate education is one of the challenges facing education in Durán, since, despite being a canton with more than a quarter of a million inhabitants, it only got its first university three years ago. The Bolivarian University of Ecuador (UBE) was officially inaugurated on May 14, 2021, and will begin its first academic period in 2022, based on a law issued by the National Assembly of Ecuador on May 4, 2021. This institution has a capacity for 10,000 students, and the investment in its first five years will be around $16 million, a million-dollar investment for the first university in Durán. (Bolivarian University of Ecuador, 2022)

It is important to mention that not only students from the canton of Durán and other localities in the province of Guayas have access to the UBE, but also students from other provinces such as Los Ríos, El Oro, Azuay, Loja, Santo Domingo de los Tsáchilas, Napo, and Pichincha, among others. Despite being geographically distant locations, the academic management of all its programs and processes takes into account all the particularities of the students, providing opportunities for all, and in this way it stands out as an inclusive Higher Education Institution (HEI), aimed at positioning itself as "The University for All."

Although UBE is a private university, from its inception, the institution has focused on being a different kind of institution, promoting access to university education for people who would not be able to achieve this goal at other institutions, not only because they have different abilities, but also because they lack the necessary financial resources, availability of days and schedules, among other factors. It is a private, non-profit legal entity that operates with its own assets and is democratic, critical, secular, inclusive, pluralistic, and supportive, with academic, administrative, financial, and organizational autonomy. In addition to face-to-face higher education, it offers other modes of study or learning, such as blended, online, distance, dual, and hybrid.

Research on scientific argumentation reveals another important contextual regularity: the universal need for teacher training to effectively implement argumentative strategies in science teaching. This regularity transcends specific

national contexts, as evidenced by the implementation of scientific argumentation in both European and North American education systems. The consistency of this training need suggests that argumentative skills represent a systematic deficit in the traditional training of health professionals who take on teaching roles.

The proposed research seeks to analyze and transform the process of training teaching skills in health science professionals who work as professors at the Bolivarian University of Ecuador. Through a systematic, multidimensional, and interdisciplinary approach, it is hoped to generate theoretical (such as an innovative model) and practical (such as an applicable strategy) contributions.

Below is a detailed analysis of each of the expected results, explaining their relevance and how they will contribute to the field of higher education in health.

Conceptual, Theoretical, and Historical Systematization of the Teaching Competency Training Process: This first result involves a comprehensive review of national and international literature on the training of teaching competencies in health professionals. Conceptual frameworks, pedagogical theories, and historical background that have shaped teaching in this field will be analyzed.

The conceptual systematization will define key terms such as "teaching competencies," "pedagogical training in health," and "medical education"; it will identify educational theories (constructivism, competency-based learning, critical education) applicable to health teaching and examine how teacher training in health sciences has evolved from traditional models to modern approaches. Recent research will be synthesized to identify gaps and trends. This analysis will lay the theoretical foundations for the research, allowing the problem to be contextualized and the need for a new model to be justified, based on the definition of the object of study itself from a critical and proactive perspective, integrating pedagogical, clinical, and technological dimensions. The evolution of health education will be periodized (e.g., traditional stage, transition to competency-based approaches, digital era), identifying trends such as clinical simulation, the use of artificial intelligence in medical education, and interdisciplinarity.

These contributions will differentiate the research from previous studies, offering an innovative perspective adapted to the Ecuadorian context.

Systematization of the Regularities of the Problematic Situation: the weaknesses in the training of health professionals will be analyzed, based on empirical evidence (surveys, interviews, observations). To this end, it is important to initially identify regularities such as lack of pedagogical training, resistance to methodological change, or a disconnect between theory and clinical practice.

This will be validated using quantitative and qualitative data that demonstrate the existence or absence of a gap in teacher training. This step is crucial to justify the research and design specific solutions.

Next, the manifestations of the problem will be demonstrated and confirmed, as it is not enough to identify the problem; its impact on educational quality must be demonstrated. Qualitative evidence, such as testimonials from students and teachers about difficulties in the teaching-learning process, and quantitative evidence, such as data on failure rates, dropout rates, or low teacher evaluations, will help validate that the problem is not merely perceived, but measurable and urgent to resolve.

The Theoretical Basis of the Proposal will follow, which will help to substantiate the model. To this end, the conceptual pillars that will underpin the proposed model will be constructed, based on integrated approaches that combine critical pedagogy, andragogy, and active methodologies (PBL, flipped classroom). To this end, components such as didactics, assessment, educational technology, and teaching ethics will be taken into account, ensuring that the model is not improvised but backed by solid theories.

Once the model is established, the theoretical contribution of the research will be available: a systematic model for the training of teaching skills in health professionals who work as teachers at the Bolivarian University of Ecuador.

The components of the model that will be considered are based on the following axes, which will be integrated into a system:

- Pedagogical axis: Teaching methods adapted to health training.
- Technological axis: Integration of educational technologies and virtual simulators for teaching and learning in Health Sciences.
- Evaluative axis: Based on teaching competencies.

The model is multidimensional as it encompasses the elements of competencies (knowledge, skills, and attitudes), flexible because it adapts to different disciplines and specialties in Health Sciences, and contextualized for the Bolivarian University of Ecuador and the entire national context, providing a frame of reference for universities and educational policies throughout the country and even the region.

Justification of the Strategy and Derived Products will be a practical contribution. An applicable strategy will be designed, with specific tools for teachers, which will include:

- Training workshops: In Health Sciences teaching.
- Methodological guides: For planning classes with a competency-based approach.
- Digital platform: Interactive resources for teachers.

This strategy will directly benefit teachers, allowing them to put theory into practice.

5.4 Validation of Theoretical and Practical Contributions: The results will be submitted for evaluation by experts and pilot testing. Theoretical validation will be carried out by specialists in medical education, and for practical validation, the strategy will be applied experimentally in classrooms at the Bolivarian University of Ecuador.

Theoretical Foundations of a Model for Teacher Competency Training

The theoretical foundations for a model of teacher competency training in health sciences professionals must be based on the convergence of pedagogical, epistemological, and professional development theories that recognize the particularities of this disciplinary field. The theory of scientific argumentation provides a fundamental conceptual framework, as it constitutes a pathway for the development of the cognitive, procedural, and attitudinal dimensions of the teaching-learning process. This theoretical basis is particularly relevant because scientific argumentation not only improves the quality of teaching but also develops critical thinking and scientific reasoning skills that are essential for health professionals.

Social constructivist epistemology emerges as another crucial theoretical basis, particularly considering that health education has evolved from individualistic approaches to community and social perspectives. This theoretical basis recognizes that knowledge is constructed through social interactions and that health determinants include environmental, social, and behavioral factors that require integrative educational approaches. The WHO definition of health as "a state of complete physical, mental, and social well-being" reinforces this theoretical perspective by recognizing the multidimensionality of the field of study.

Theories of professional competency development provide a third fundamental theoretical basis. Research on teaching competencies in university professors of health sciences shows that competencies develop differentially according to specific dimensions (Fernández & Castillo, 2023). This empirical evidence suggests that the theoretical foundations of the model should incorporate adult

learning theories that recognize prior professional experiences as resources for teacher development, while simultaneously addressing specific deficiencies in pedagogical training.

Complex adaptive systems theory offers a fourth essential theoretical basis for understanding the interaction between disciplinary and pedagogical competencies. Findings indicating that the least developed competencies correspond to the cognition of the disciplinary function and the management of the teaching-learning process suggest that there is a systematic disconnect between disciplinary knowledge and its pedagogical transfer (León, 2017). This theoretical basis implies that the model must explicitly address the interfaces between disciplinary knowledge, pedagogical knowledge, and pedagogical content knowledge.

Elements of a Systemic Model for Teacher Competency Training

A systemic model for teacher competency training in health sciences professionals must integrate multiple interconnected elements that address both identified strengths and systematic deficiencies in competency development (Triviño et al., 2024). The first fundamental element consists of a multidimensional diagnostic system that evaluates the four competency dimensions identified in the research: cognition of the disciplinary function, management of the teaching-learning process, metacognition, and communication, socialization, and disposition to teaching (Samaniego, 2023). This diagnostic element must be sensitive enough to detect individual variations while maintaining the ability to identify systematic patterns of strength and weakness.

The second essential element of the systemic model involves the integration of scientific argumentation strategies as a cross-cutting pedagogical tool. Given that scientific argumentation facilitates the development of scientific reasoning skills, critical thinking, and argumentative presentation skills, this element should include specific techniques such as scientific discussion, tournament-style debate, academic controversy, and evidence-based dialogue maps. The implementation of these components requires a structured progression that allows professionals to gradually develop their argumentative competence (Espinoza, 2020).

A third crucial element is the development of advanced metacognitive skills that transcend those already existing in health professionals. Although research indicates that metacognition represents one of the most developed dimensions (Reyes et al., 2024), the systemic model must deepen this competence to higher levels that include critical reflection on teaching practice, self-regulation of continuous professional learning, and the ability to adapt pedagogical strategies

to specific contexts. This metacognitive element must be systematically connected to the professionals' previous clinical experiences to facilitate the transfer of reflective skills.

The fourth element of the systemic model must specifically address the deficiencies identified in the management of the teaching-learning process and the cognition of the disciplinary function. This element requires the development of specific pedagogical competencies that include curriculum design, learning assessment, use of educational technologies, and management of learning environments. In addition, it should strengthen the understanding of how disciplinary knowledge is transformed into teachable knowledge, incorporating specific didactic transposition principles for the Health Sciences (Richard and Richard, 2024).

Implementation of a Multidimensional Systemic Model with a Comprehensive and Interdisciplinary Approach

The effective implementation of a multidimensional systemic model for the development of teaching competencies requires a comprehensive strategy that considers the specific institutional, contextual, and disciplinary characteristics of the Bolivarian University of Ecuador. The first component of implementation should establish an organizational structure that facilitates coordination between different departments and faculties, promoting a truly interdisciplinary approach that reflects the multifaceted nature of Health Sciences. This structure should incorporate representatives from various medical specialties, nursing, pharmacy, dentistry, and other health disciplines to ensure the relevance and applicability of the model in different disciplinary contexts.

The initial implementation phase should include a comprehensive teacher training process that addresses identified deficiencies in the management of the teaching-learning process. This training should be designed specifically for health professionals, recognizing their existing strengths in metacognition and socialization while systematically developing technical pedagogical skills. The training program should incorporate active learning methodologies, including scientific argumentation as a central tool for the development of critical thinking and scientific reasoning.

The comprehensive approach to implementation requires the creation of interdisciplinary communities of practice that facilitate the exchange of experiences and knowledge among professionals from different specialties. These communities should function as spaces for reflection and continuous improvement, where participants can analyze specific cases, share successful pedagogical strategies, and collaborate on the development of innovative educational materials. The structure of these communities should reflect the

principles of community health education, applying participatory methodologies that have proven effective in public health contexts (Suárez et al, 2023).

Multidimensional implementation should include a robust support and mentoring system that connects experienced teachers with those in the process of developing teaching skills. This mentoring system should be designed to specifically address the needs of health professionals transitioning to educational roles, providing support in both technical aspects of teaching and the development of teaching identity. The mentoring program should incorporate methodologies for classroom observation, constructive feedback, and collaborative planning of educational activities (Espinoza Barreiro et al., 2024).

Aspects for the Scientific Validation of the Model and Proposed Strategy

The process of scientific validation of the model and strategy for the development of teaching skills must incorporate multiple methodological approaches that ensure the rigor, reliability, and validity of the results obtained. The first crucial aspect for validation involves establishing specific and measurable evaluation criteria that correspond to each of the identified competency dimensions: cognition of the disciplinary function, management of the teaching-learning process, metacognition, and communication, socialization, and disposition to teaching (Diaz et al., 2024). These criteria must be developed collaboratively with experts in medical education and university pedagogy to ensure their content validity and disciplinary relevance (Ávila et al., 2023).

Empirical validation should include a quasi-experimental research design that allows for the evaluation of the model's effectiveness by comparing control and experimental groups. This design should incorporate pre- and post-intervention measurements using validated instruments to assess teaching competencies, complemented by student performance evaluations and perceptions of educational quality. Data analysis should include descriptive statistics, analysis of variance, and correlations, following methodologies similar to those used in previous research on teaching competencies in university health professionals (Richard, 2025).

A fundamental aspect of validation is the evaluation of the implementation of scientific argumentation strategies as a central component of the model. This evaluation should examine the progressive development of argumentative skills in participants, using methodologies that analyze the quality of the arguments produced according to established levels: basic argumentation, arguments with data and supporting evidence, series of claims, arguments with clearly identifiable identity, and systematic arguments with multiple refutations. The

evaluation should include qualitative analyses of argumentative productions and quantitative analyses of the progression in levels of competence (Díaz and Jara, 2010).

Validation should incorporate aspects of ecological validity by evaluating the model in real conditions of institutional implementation. This requires the development of multiple case studies that examine the implementation of the model in different departmental contexts within the Bolivarian University of Ecuador, analyzing contextual factors that facilitate or hinder the effectiveness of the model. Ecological validation should include in-depth interviews with participants, observations of training activities, and documentary analysis of products generated during implementation.

Conclusions

The training of teaching competencies in health sciences professionals represents a multidimensional challenge that requires systemic and integrated approaches to effectively address the complexities inherent in the intersection between specialized disciplinary knowledge and pedagogical competencies. Scientific evidence consistently shows that these professionals naturally develop competencies related to metacognition, socialization, and disposition toward teaching, while exhibiting systematic deficiencies in the management of the teaching-learning process and cognition of the disciplinary function. This asymmetrical distribution of competencies underscores the need for training models specifically designed to leverage existing strengths while addressing identified deficiencies through innovative pedagogical strategies such as scientific argumentation.

The successful implementation of multidimensional systemic models requires a deep understanding of the contextual regularities that characterize health professionals in teaching roles, as well as the development of rigorous scientific validation strategies that ensure the effectiveness and sustainability of training interventions. The convergence of historical trends in health education, contemporary theories of scientific argumentation, and empirical evidence on the development of teaching skills provides a solid foundation for the transformation of educational practice in the health sciences, contributing significantly to the improvement of higher education quality and the training of future health professionals who are better prepared to face the challenges of the 21st century.

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Design and implementation of a continuing education model on breast cancer for nursing students

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Introduction

Breast cancer is a serious public health problem worldwide and nationally, being the most common neoplasm and the leading cause of cancer death in women in most countries. According to the World Health Organization (WHO, 2023) report, more than 2.3 million new cases of breast cancer are diagnosed each year, with a mortality rate exceeding 685,000 cases annually. Although advances in early diagnosis and treatment have reduced mortality rates in some developed countries, significant inequalities in care, access to cancer services, and health education persist, especially in low- and middle-income regions.

Therefore, knowledge, prevention, and early diagnosis are essential elements in reducing the impact of breast cancer. For this reason, various international organizations, such as the Pan American Health Organization (PAHO), have promoted educational strategies aimed at health professionals and the general population. In this context, nursing staff play a fundamental role in health promotion, community education, emotional support, and follow-up of patients diagnosed with this disease. However, multiple studies have shown deficiencies in academic training related to oncology, and specifically breast cancer, which affects the ability of future professionals to respond to this problem.

Internationally, continuing education programs have been developed in universities to improve the level of knowledge and practical skills of nursing staff regarding breast cancer. For example, in countries such as the United States, Canada, and the United Kingdom, curricula with specific modules on oncology have been implemented during undergraduate training, as well as ongoing training programs aimed at strengthening clinical, communication, and support skills for cancer patients. In Latin America, countries such as Mexico, Brazil, Colombia, and Chile have made progress in including cancer-related training content in their university programs, although there are still significant gaps between theoretical knowledge and its practical application.

Likewise, in a study conducted by Vásquez et al. (2020) in Mexico found that more than 60% of final-year nursing students had insufficient knowledge of risk factors, signs, and symptoms of breast cancer, highlighting the need to strengthen educational competencies through continuous training processes,

including innovative teaching strategies such as problem-based learning, clinical simulations, and community practices.

In this regard, the training of nursing staff in Ecuador faces significant challenges. Various studies have reported that the curricula of the country's universities still have significant gaps in terms of comprehensive oncology training, especially in the approach to breast cancer. A recent study by Ortiz-Montalvo et al. (2023), which assessed knowledge about breast cancer among nursing students at three universities in the country, revealed that 70% of respondents were unaware of key aspects related to self-examination, early detection techniques, and associated risk factors. This finding highlights an urgent need to strengthen continuing education processes in university training (Duche et al., 2024).

Traditionally, undergraduate nursing programs have approached breast cancer from a theoretical and fragmented perspective, focusing mainly on biomedical aspects and lacking comprehensive, preventive, and humanistic approaches, without incorporating active methodologies that integrate clinical knowledge with pedagogical tools for health promotion. This training gap limits the transformative role that future professionals can assume in clinical, family, and community contexts. In order to overcome this limitation, there is a need to design and implement a continuing education model that articulates biomedical knowledge with the development of humanistic, ethical, and communication skills.

Therefore, this article proposes an innovative model of continuing education on breast cancer, aimed at undergraduate nursing students. This model is based on active, flexible, and contextually relevant pedagogical principles that seek not only to transmit knowledge but also to transform training practices around a high-impact public health problem. It is also conceived as a replicable strategy aimed at strengthening students' professional profile and their ability to positively influence primary and secondary prevention levels.

From a research and educational perspective, this work seeks to respond to a real need in the health education system: to integrate continuing education models that prepare future nurses not only to respond to the disease, but also to lead processes of promotion, education, and comprehensive support in breast cancer, with a focus on rights, gender, and equity.

Justification for the research

The purpose of this study responds to the urgent need in the field of professional health training, especially in the context of developing countries such as Ecuador. Breast cancer, due to its high prevalence and physical, emotional, economic, and social impact, requires a comprehensive response that includes

not only clinical strategies, but also educational, preventive, and community strategies. In this sense, the role of the nursing professional is decisive, as their proximity to the patient and their ability to influence health education position them as a key agent in the fight against this disease (Ochoa and Balderas, 2021).

Despite this, numerous studies and curriculum assessments have revealed significant gaps in university nursing education regarding the approach to breast cancer. These gaps are not only evident in the limited number of hours devoted to oncology content, but also in the absence of active methodologies that promote critical thinking, continuing education, applied research, and community practice around this issue. Therefore, the design and implementation of a specific educational model aimed at strengthening students' skills in this field represents a significant contribution to both academia and the health system (Obregón-Sánchez et al., 2023).

Therefore, this article proposes a contextualized and relevant training strategy, aligned with the principles of continuing education, public health approaches, and contemporary pedagogical trends. This model seeks to promote meaningful and lifelong learning that will enable future nursing professionals to take an active role in breast health promotion, breast cancer prevention, early detection, and comprehensive patient support. It also promotes a humanistic vision of care, based on ethics, empathy, and equity, which are essential elements in oncological care (Negi, 2023).

Likewise, from an academic point of view, we can contribute to the construction of a new training framework that can be replicated or adapted in other universities in the region, which strengthens its potential for impact and innovation. Furthermore, from a research perspective, the validation of an educational model focused on breast cancer will generate scientific evidence on its effectiveness, relevance, and transformative capacity within university nursing education processes. This is a relevant, timely, and necessary topic, as it links higher education with one of the main contemporary public health issues and offers a concrete solution through professional training. By positioning continuing education as the central axis of the model, the response capacity of future nursing staff to breast cancer is strengthened, thereby contributing to improving the quality of life of women and reducing the burden of disease on society (Ocampo 2019).

In Ecuadorian universities, a recurring weakness has been identified in the training of nursing students with regard to the approach to breast cancer. Despite being one of the most prevalent and deadly diseases among women in the country and worldwide, future professionals have limited knowledge of its

prevention, early detection, current treatments, and community-based health education strategies (Guia, 2019).

This lack of training not only compromises the academic development of students, but also directly affects their professional performance during clinical practice, where they show poor preparation in identifying warning signs, guiding patients, and actively participating in breast health promotion activities. Although there has been a high level of interest among students in updating their knowledge and acquiring more solid skills in this area, the institutional provision of continuing education and specific training in oncology, particularly breast cancer, remains limited, sporadic, and poorly structured (Hernández et al., 2022).

Added to this reality is the rapid evolution of cancer treatments, diagnostic technologies, and comprehensive care strategies, which require nursing professionals to constantly update and adapt to new scientific and clinical contexts. However, there remains a significant gap between scientific advances in breast cancer and the actual preparation that students receive in university classrooms, which represents a structural weakness in the training process (Julca-Lázaro et al., 2024).

Consequently, there is an urgent need to strengthen pedagogical strategies by implementing a specific continuing education model focused on breast cancer that guarantees a more comprehensive, up-to-date, and contextualized education. This model must be capable of integrating current scientific knowledge with innovative and humanistic educational practices that prepare students not only technically, but also ethically, empathetically, and communicatively (Méndez and Rojas, 2024).

The need, therefore, is not only curricular, but also social and professional. Training nurses who are able to face the challenges of breast cancer with competence, sensitivity, and up-to-date knowledge is an indispensable condition for improving the quality of health care and reducing diagnostic and treatment gaps in the population. Thus, a transformation is required in the university educational approach that prioritizes continuous and systematized training models, based on the real demands of the clinical and community environment (Kiri and Ryba, 2024).

Furthermore, training in breast cancer should not be limited to the acquisition of technical and clinical knowledge, but should encourage nursing students to develop cross-cutting skills such as critical thinking, empathy, and solidarity. These elements are essential for future professionals to understand not only the scientific dimension of the disease, but also its emotional, social, and family

impact on patients' lives. Critical thinking will enable them to analyze different clinical scenarios in depth and with discernment, make informed decisions, and propose contextualized solutions (Maslow, 1991).

In turn, empathy and solidarity will strengthen their ability to establish authentic human relationships with patients and their families, which is essential in comprehensive and humanized breast cancer care. Therefore, a continuing education model must incorporate not only up-to-date academic content, but also pedagogical strategies that promote an ethical, sensitive, and committed vision of care (Hernández et al., 2020).

Faced with this educational and healthcare reality, there is a need to propose a hypothesis that guides the construction of innovative and relevant academic solutions for the current university and social context.

Conceptual basis of the topic

In order to understand the subject of study from a comprehensive perspective, it is essential to establish the key concepts, theories, and approaches that allow for the identification, organization, and interrelation of the central elements of the research. This conceptual delimitation enables the construction of a coherent and well-founded theoretical framework that serves as a solid basis for the development of the study and ensures its anchoring in existing scientific knowledge. In this context, the unique concepts will be presented, which will give rise to the author's own definition of the object of study, thus allowing for a structured and contextualized understanding of the phenomenon under investigation.

Continuing education process

The **continuing education process** is an approach to constant, lifelong learning that aims to improve the competencies and skills of professionals in their specific field. This process involves the participation of individuals in training and refresher activities that allow them to keep up with advances, innovations, and changes within their area of knowledge or professional practice. Continuing education can take various forms, such as courses, workshops, seminars, conferences, postgraduate studies, and learning through digital platforms, and is aimed at responding to both individual needs and the changing demands of the professional and social environment, promoting personal and professional development (Ramírez et al., 2022).

Meanwhile, Flores (2023) defines it as a cyclical learning process that involves direct experience, reflection on that experience, conceptualization of new ideas, and application of that acquired knowledge in practical situations. In his approach, learning does not end with the completion of a course or initial

training, but is a continuous process in which professionals develop their skills through experience and reflection, which is particularly relevant in fields such as nursing, where constant interaction with patients and diverse situations offers new learning opportunities (Larez et al., 2023).

As can be inferred, continuing education is a learning process in which knowledge and skills are acquired and updated throughout one's life to meet personal and professional needs, involving educational activities that are relevant to one's interests and needs. This approach emphasizes the student's responsibility to manage their own learning, adapting to changes in their professional and personal environment. In the context of health, this type of education allows professionals to keep up to date with scientific advances and improve the quality of care provided.

Continuing education process for nursing students

Continuing education in nursing refers to the education and training that nursing professionals receive after their initial training. Its main objective is to maintain and improve professional competencies, adapt to scientific and technological advances, and respond to emerging demands in the health system. (Jiménez, 2022)

Pavloff and Labrecque (2021) define it as a planned and systematic process that allows nursing professionals to keep up to date with knowledge, skills, and attitudes, promoting improvement in the quality of patient care. This process encourages practice based on evidence and technological and scientific advances, focusing on the comprehensive training of future professionals and promoting autonomous learning, critical reflection, and ethical commitment.

In this regard, we can define it as a systematic and structured set of training activities aimed at updating, perfecting, and strengthening the theoretical, practical, and ethical competencies of future nursing professionals. This process integrates educational objectives, pedagogical methods, relevant content, and constant evaluations, with the aim of promoting dynamic, reflective, and adaptive learning. In addition, it facilitates the development of problem-solving skills in complex clinical contexts, ensuring that students are prepared to provide quality care based on scientific and humanistic principles (Loaiza-Zuluaga et al., 2020).

Concept specific to our object of study

On the other hand, in order to arrive at a conceptualization of our research object, Continuing education process on breast cancer for undergraduate nursing students at Ecuadorian universities, we draw on the research of Watson, (2013), author of the Theory of Human Care, whose vision integrates the

technical-scientific component with the emotional, spiritual, and relational dimensions of the human being. From this perspective, the act of caring constitutes the essential core of nursing and requires that the professional not only possess solid clinical knowledge but also an ethical, empathetic, and humanized attitude toward the patient. In the context of breast cancer, a disease with profound physical and emotional implications, this theory is particularly relevant, as it promotes professional training focused on comprehensive support, reinforcing the importance of designing a continuing education process that prepares nursing students to provide care that goes beyond treatment, also addressing the psychological and social impact of the diagnosis. In this sense, our research objective is based on the need to train caregivers who are aware that their intervention can significantly transform the patient's experience and, at the same time, enrich their own professional and human development (Madero, 2023).

Likewise, Benner (1984), with her "From Novice to Expert" model, contributes to understanding how nursing professionals develop their clinical competencies and skills over time through a continuous process of learning and practical experience. This model emphasizes that the professional development of nurses occurs through practice-based learning. this progressive education must be designed in such a way as to support the student's growth throughout their training, from the earliest levels to advanced practice, particularly in complex fields such as breast oncology, highlighting the need for a structured pedagogical approach that combines theory, practice, and critical reflection, which is essential to achieving our definition of the object of our research.

Therefore, based on the different conceptualizations made and the contribution of theorists, we can define our research objective as the set of systematic, planned, and progressive training actions that aim to strengthen and update the knowledge, skills, and attitudes of future nursing professionals in relation to the prevention, early detection, treatment, and support of breast cancer. This process is based on an updated and interdisciplinary educational model that integrates the latest scientific evidence, active learning methodologies, and practical experiences in clinical settings, with the aim of improving professional preparation and the quality of healthcare, allowing for the effective integration of theoretical knowledge with clinical practice, thus contributing to the preparation of competent, critical nurses who are committed to public health (Martina, 2024).

As a central result of this research, the design and projection of a continuing education model on breast cancer aimed at students in the Bachelor of Nursing program at Ecuadorian universities. The purpose of this model was to comprehensively strengthen the training of future professionals, not only in

technical and scientific aspects, but also in the human, ethical, and social dimensions that are fundamental to providing quality care to patients with this disease.

Therefore, it was projected that the implementation of the model would contribute to a significant improvement in the level of scientific knowledge about breast cancer. Students were able to acquire up-to-date knowledge on its pathophysiology, risk factors, diagnostic methods, treatment modalities, and specific nursing care, supported by scientific evidence and international clinical guidelines. This solid theoretical foundation made it possible to reduce the learning gaps that currently limit their performance in real clinical settings.

Likewise, it was estimated that the model would promote the development of critical thinking and reflective analysis skills in students. Through active and participatory teaching methodologies, such as problem-based learning, case studies, clinical simulations, and ethical discussions, students were able to analyze complex situations and make informed decisions from both a clinical and humanistic perspective.

Another important outcome was the strengthening of attitudinal competencies, especially empathy, solidarity, and therapeutic communication. These qualities are essential for establishing authentic and humanized professional relationships with patients diagnosed with breast cancer. The model included activities aimed at developing these skills, such as analyzing testimonials, reflecting on life experiences, training in palliative care, and emotional management in the oncological context.

Similarly, a reduction in the gap between theory and practice was established. The proposal included opportunities for direct interaction with the clinical and community environment, such as educational workshops in health centers, visits to oncology units, workshops with specialists, and university outreach projects focused on breast cancer prevention. This facilitated the effective application of classroom knowledge in real-world contexts, increasing the relevance of the training process.

In addition, a structured, replicable, and theoretically validated educational product was generated that can be adapted by other higher education institutions interested in strengthening the training of their students in priority areas of public health. This model not only contributed to pedagogical innovation but is also a useful tool for curriculum planning, the redesign of specific subjects, and the continuing education of teaching staff.

Finally, the development of this proposal will lead to the formulation of institutional guidelines that promote a culture of continuous updating within the

university curriculum. This will drive a commitment to a more dynamic, critical, and contextualized professional education, aligned with the current needs of the health system and with social demands related to breast cancer prevention and care in Ecuador.

The implementation of the continuing education model on breast cancer for nursing students at Ecuadorian universities promises significant contributions in both the academic and health fields. The findings show that this model has the potential to close persistent training gaps, especially with regard to a comprehensive understanding of breast cancer, one of the leading causes of morbidity and mortality in women worldwide and nationally.

In line with previous studies, it is recognized that universities face the challenge of offering educational programs that are more sensitive, up-to-date, and adapted to the epidemiological realities of the environment. The scientific literature has shown that traditional training models, focused exclusively on theoretical transmission, are insufficient for developing solid clinical skills and humanistic attitudes in future nursing professionals. In this sense, the proposed model is aligned with contemporary educational trends that promote active teaching, theory-practice integration, and a competency-based approach.

Likewise, it highlights the importance of strengthening critical thinking, given that this is an essential competency for clinical judgment, decision-making, and problem-solving in complex scenarios. The model seeks precisely to stimulate this capacity through methodologies that challenge academic passivity and encourage deep reflection, ethical analysis, and constant questioning, which are key elements for comprehensive training. This approach is based on the defense of the systematic inclusion of critical thinking in the teaching-learning processes in health sciences.

On the other hand, the results also highlight the role of attitudinal competencies, especially empathy, solidarity, and therapeutic communication, as pillars of truly humanized care. Numerous studies have confirmed that the quality of the nurse-patient relationship has a direct impact on treatment adherence, emotional well-being, and satisfaction among cancer patients. In this context, the model not only provides technical tools, but also training elements that sensitize students to human suffering and the need for ethical and compassionate care (Flores et al., 2024).

Another key aspect of the discussion is the institutional relevance of the model. Within the framework of the university curriculum, its implementation can contribute to the redesign of courses, the continuing education of faculty, and the effective articulation between theoretical and practical levels of training. This

contribution is particularly valuable in contexts such as Ecuador, where public health challenges require professionals with comprehensive training, critical thinking, and social commitment.

Furthermore, the fact that the model is conceived as a replicable, evaluable, and scalable tool makes it a proposal with potential for transfer to other degree programs, faculties, and institutions. This increases its value as an academic resource and as an educational innovation in health. Its multi-methodological and multi-paradigmatic approach gives it a flexible and adaptable structure, ideal for responding to the dynamic demands of the higher education context and the health system (García, 2024).

In short, the results not only validate the need to transform breast cancer teaching in nursing education, but also reflect an effort to propose well-founded, contextualized educational solutions committed to academic excellence and the well-being of society. This proposal constitutes a viable strategy for moving toward more critical, empathetic, and effective professional training, aligned with the real needs of patients and the contemporary demands of nursing practice.

Conclusions

This study has allowed us to highlight the urgent need to transform and strengthen the training processes in the Bachelor of Nursing degree program, especially in relation to continuing education on breast cancer. The identification of weaknesses in the acquisition of clinical and scientific knowledge, as well as in the development of attitudinal skills such as empathy, solidarity, and critical thinking, justifies the construction of a comprehensive educational model that responds to these shortcomings from a dialectical, critical, and contextualized perspective.

The proposal for a theoretical-practical continuing education model, with a multi-paradigmatic and competency-based approach, is projected as an innovative academic strategy to significantly improve the quality of professional nursing education. This model not only seeks to update scientific knowledge about breast cancer, but also to promote humanized, ethical, and empathetic care, aligned with the real needs of patients and the Ecuadorian health system.

Among the most relevant contributions of this research are the creation of a replicable academic product, the promotion of critical reflection and social commitment in future professionals, and the strengthening of the theory-practice relationship through spaces for integration with the community and the hospital environment. In addition, this model stands as a strategic tool for higher

education institutions, offering a clear and well-founded way to renew their pedagogical practices in the field of health.

The development and implementation of this model represents a significant contribution to both the academic sphere and the public health system. It constitutes a firm step toward the training of nursing professionals who are better prepared, more humane, more critical, and more committed to comprehensive breast cancer care, thus consolidating the transformative role of higher education in building a more equitable and healthy society.

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Formative assessment innovations in higher education in the context of the covid-19 pandemic. systematic review

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Introduction

Evaluation constitutes a cross-cutting dimension in the consolidation of learning within Higher Education and acquires particular relevance in contexts of educational transformation (IESALC-UNESCO, 2022). Specifically, Formative Assessment (FA) has emerged as a fundamental strategy in contemporary educational policies, promoting quality learning through flexible pedagogical practices designed to address contextual needs in depth. Nevertheless, its systematic implementation in university classrooms remains an ongoing challenge, limiting the realization of its transformative potential (Popham, 2013; Beriche & Medina, 2021).

Given this context, it is essential to analyze FA innovation processes from a perspective that examines their approaches, orientations, and concrete manifestations. As suggested by Fullan and Hargreaves (1999) and Sangrá (2020), innovation should transcend the mere adoption of new methodologies to constitute a systemic transformation of assessment practices and institutional cultures, aiming to consolidate pedagogical knowledge and generate sustainable improvements.

The COVID-19 pandemic underscored the need to assess innovation risks and reflect on their foundations, revealing the importance of strengthening Higher Education resilience in adopting emergency remote education (UNESCO, 2020;

Reimers & Schleicher, 2020). In this context, FA gained renewed relevance by requiring new digital interactions to support learning and student self-regulation, while also creating opportunities to better integrate technology within Higher Education (Fernández et al., 2021).

Based on these considerations, this study employs a systematic review to analyze innovations in FA implemented in Higher Education in response to the challenges of the COVID-19 pandemic between 2020 and 2022, aiming to elucidate relevant aspects and central foci of these transformations. Unlike previous reviews analyzing FA without problematizing the innovation approach (Heil & Ifenthaler, 2023; Sudakova et al., 2022; Asamoah et al., 2022; Morris et al., 2021), this research adopts an analytical perspective enabling the identification of patterns, trends, and core orientations within these transformations.

Furthermore, the systematic review we have undertaken prioritizes research documenting the effective application of improvements in FA practices; specifically, studies providing evidence of concrete transformations implemented during the analyzed period. This ensures a perspective grounded in real, context-specific changes.

The study was conducted between April and November 2023. Specific roles were assigned to each researcher for inquiry, review and document systematization in each phase. Process replicability was guaranteed, and bias risk was controlled with the ROBIS tool. To select specialized databases, a broad criterion was considered that implied not only considering mainstream scientific production. Six databases were consulted: Scopus, WoS (Web of Science), SciELO (Scientific Electronic Library Online), Dialnet, Ebsco and DOAJ (Directory of Open Access Journals). Table 1 presents the inclusion and exclusion criteria.

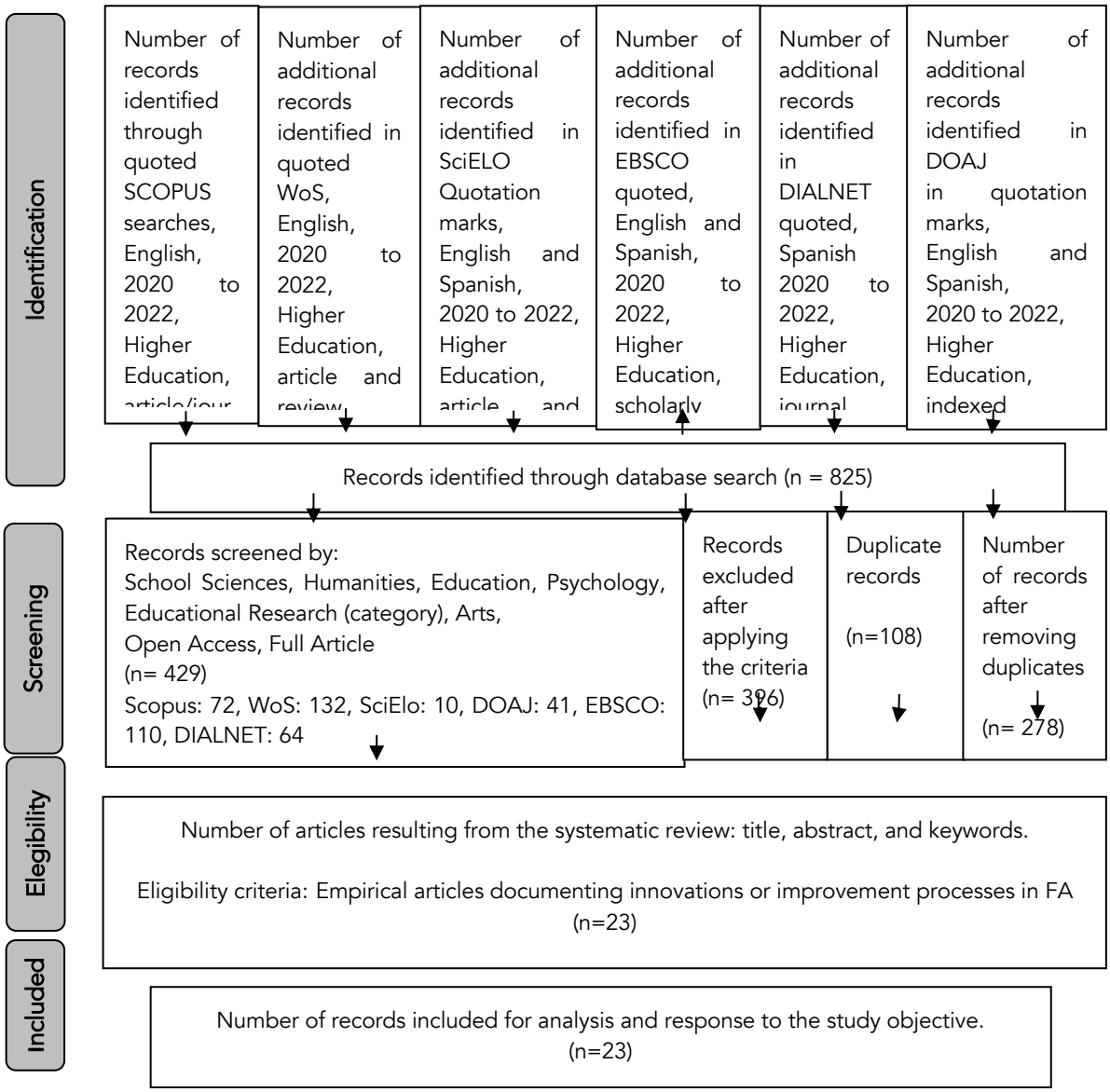
Table 1. Inclusion and Exclusion Criteria

Main Axes	Inclusion Criteria	Exclusion Criteria
Search terms	Evaluación formativa Formative assessment	Other unrelated assessment terminologies
	Educación superior Higher Education	Other educational levels other than Higher Education
Temporality	2020 a 2022	Before 2020 and after 2022.
Document type	Open Access Scientific articles	Books, book chapters, theses or scientific articles with restricted access.
Language	Spanish and English	Languages other than those included
Thematic area	Social Sciences and Humanities	Other sciences and disciplinary areas

Purpose and central orientation of the study	Scientific articles documenting FA improvement processes	Theoretical or review articles, or empirical articles that do not document EF improvement processes.

For duplicate detection, Rayyan Artificial Intelligence was used with files exported in CSV and RIS format from Scopus, WoS, SciELO and Ebsco, while for Dialnet and DOAJ, a manual procedure was applied due to the absence of export function. Reference management was performed with Zotero, allowing systematic treatment of records as detailed in Figure 1.

Figure 1. Flow Chart



In the identification phase, the search used "Evaluación formativa" and "Formative Assessment" with filters por 2020-2022, Higher Education, and article-type documents by database, yielding 825 results. In the screening phase, open-access, full-text articles in social sciences, humanities, education, psychology, educational research, and arts were retained, reducing the set to 429 documents after excluding 396.

Subsequently, duplicate detection and elimination was performed. 108 duplicates were identified through two procedures: for Scopus, WoS, SciELO and Ebsco, the mentioned artificial intelligence tool was used through RIS format; while for Dialnet and DOAJ, manual review was applied. This process resulted in 278 files.

In the eligibility phase, 278 empirical articles documenting innovations or improvement processes in FA were reviewed, distributed among researchers for full review and cross-verification, resulting in 23 articles. In the inclusion phase, these 23 were again distributed for content systematization aligned with the study's objective, followed by a joint review to verify results.

In results, Table 2 shows the 23 studies including title, authors, year of publication and Database source.

Table 2 . List of selected articles

Number Code	Article Name	Author/s	Database	Year of Publication
A1	A feedback model applied in a ubiquitous microlearning environment using SECA rules	Tabares, M.S., Vallejo, P., Montoya, A. & Correa, D.	Scopus	2022
A2	An analysis of internal and external feedback in self-regulated learning activities mediated by self-regulated learning tools and open learner models	Chih-Yueh, C. & Nian-Bao, Z.	Scopus	2020
A3	Application of Artificial Intelligence powered digital writing assistant in Higher Education: randomized controlled trial	Nazari, N., Salman Shabbir, M. & Setiawan, R.	WoS	2021
A4	¿Cómo implicar a los estudiantes para que utilicen el feedback online?	Espasa, A., y Guasch Pascual, T.	WoS	2021
A5	Combined inner and outer loop feedback in an intelligent tutoring system for statistics in Higher Education	Tacoma, S., Drijvers, P. & Jeuring, J.	Scopus	2020
A6	Competencias profesionales de futuros docentes de educación secundaria. estudio de caso de la evaluación formativa promovida mediante e-rúbricas en la especialidad de física y química	Lupión-Cobos, T. y Caracuel-González, M.	Dialnet	2021
A7	Evaluación formativa, autorregulación, feedback y herramientas digitales uso de Socrative en educación superior	Fraile, J.; Ruiz-Bravo, P.; Zamorano-Sande, D. y Orgaz-Rincón, D.	Dialnet	2021
A8	Evaluating the use of e-assessment in a first-year pure mathematics module	Zegowitz, S.	Scopus	2022

A9	Evaluation of a Mobile Web Application for Assessment Feedback	Bikanga Ada, M.	Scopus	2021
A10	Finally studying for myself' – examining student agency in summative and formative self-assessment models	Nieminen, J.H. & Tuohilampi, L.	WoS	2020
A11	How does the medium affect the message? Architecture students' perceptions of the relative utility of different feedback methods	Smith, C.	Scopus	2021
A12	Improving the understanding of written peer feedback through face-to-face peer dialogue: students' perspective	Schillings, M., Roebertsen, Savelberg, H., van Dijk, A. & Dolmans, D.	WoS	2020
A13	La retroalimentación escrita en la producción escrita del francés L2	Chao, K. y Durand, M.	SciELO	2021
A14	Making internal feedback explicit: harnessing the comparisons students make during two-stage exams	Nicol, D. & Selvaretnam, G.	Scopus	2021
A15	Self- and Peer-Assessment of Student-Generated Podcasts to Improve Comprehensibility in Undergraduate EFL Students	Cadena-Aguilar, A. & Álvarez-Ayure, C.	Scopus	2021
A16	Stimulating Higher Education students to use online formative assessments: the case of two mid-term take-home tests	Blondeel, E., Everaert, P. & Opdecam, E.	WoS	2021
A17	Student experiences of live synchronized video feedback in formative assessment.	Wilkie, B. & Liefeith, A.	Scopus	2022
A18	Students' perceptions and use of a new digital tool in teacher education	Bamer, M., Home-Iversen, S. & Burner, T.	WoS	2021
A19	Supervisors' untrained postgraduate rubric use for formative and summative purposes	Postmes L., Bouwmeester, R., de Kleijn, R. & van der Schaaf, M.	Scopus	2022
A20	Supporting Peer Feedback on Learning Strategies: Effects on Self-Efficacy and Feedback Quality	Burgermeister, A., Glogger-Frey, I. & Saalbach, H.	Scopus	2021
A21	The digital portfolio as an assessment strategy for learning in Higher Education	Marinho, P., Fernandes, P. & Pimentel, F.	Scopus	2021
A22	The effectiveness of formative assessment: student views and staff reflections	McCallum, S. & Milner, M.	Scopus	2020
A23	The evaluation of an evidence-based model of feedback implemented on an undergraduate dental clinical learning environment	Davis, S., Duane, B., Loxley, A. & Quigley, D.	Scopus	2022

Context and Origin Report

To contextualize the analysis, Table 3 presents the geographical distribution of the 23 articles by country and continent of origin.

Table 3. Place of origin of the articles

Continent	Country	Total	%
Europe	Spain (n=3), Netherlands (n=4), United Kingdom (n=6), Belgium (n=1), Norway (n=1), Portugal (n=1), Ireland (n=1)	17	74%
Asia	Taiwan (n=1); Iran, Oman & Indonesia (n=1)	2	9%
Latin America	Colombia (n=2), Costa Rica (n=1)	3	13%

Multicontinent (Europe y Oceania)	Finland y Australia (n=1)	1	4%

Results show European concentration with 17 studies (74%), with United Kingdom (6), Netherlands (4) and Spain (3) predominance. Latin America contributes 3 studies (13%) and Asia, 2 (9%). Finally, 1 study (4%) involved two countries from different continents.

Keyword Analysis Results

Keywords analysis revealed six thematic categories (Table 4). The first three cover methodological aspects: teaching/assessment approaches, feedback models, and assessment tools (Gimeno-Sacristán, 2010). Another category includes keywords on capacities and cognitive processes tied to self-regulation. The last two, at the contextual level, distinguish between general educational scenarios (e.g., levels, competencies) and those focused on virtual learning environments (Fiedler & Väljataga, 2011).

Table 4. Organization of keywords according to proposed analysis categories

N°	Categories	Description	Keywords
1	Approaches and methodologies	This category includes keywords that refer to approaches, methodologies, or strategies related to teaching, learning, or, specifically, assessment.	ECA rules, Pedagogy, Formative assessment, Reelaboration, Teaching practice, Self-assessment, Peer-assessment, Co-regulation, System evaluation, Self-assessment, Summative self-assessment, Dialogue, Two-stage exams, Comparison, Learning strategies, Assessment for learning y Assessment.
2	Models or types of feedback	This category involves keywords that refer to feedback models or specific strategies based on them.	Feedback rules model; Internal feedback, External feedback, Feedback Enhanced assessment feedback, Summative feedback, Formative feedback, Feedback utility, Dialogic feedback, Peer feedback, Written Feedback, Internal feedback, Peer feedback, Feedback effectiveness y Model of feedback.
3	Tools	This category includes words that may refer to technological or methodological tools linked to evaluation.	Computer tools, Artificial Intelligence, Automated writing evaluation, Domain reasoner, Inspectable student models, Rubrics, ICT, Podcasts, Intermediate, tests, Video feedback, Digital tools, Digital tool, Digital portfolio y E-assessment.
4	Cognitive capacities or processes linked to self-regulation	This category involves keywords referring to cognitive aspects, broadly understood, related to how students manage and regulate their own learning.	Learning process, Self-regulated learning, Engagement, Agency, Self-directed learning, Procrastination, Reflective practice y Self-efficacy.
5	Virtual learning	This category involves keywords that refer to different types of virtual environments	Ubiquitous microlearning environment, Ubiquitous context, Open learner model, Online, Intelligent tutoring systems,

	environments	intentionally organized for learning development.	Technology, E-assessment, Technology, Mobile learning, online formative assessment, Blended learning y Clinical learning environment.
6	Training contexts	This category involves words that refer to the level or modality of training, discipline or objectives in which learning is developed.	L2 writing, ESL, Higher Education, Statistics education, master's degrees, Teacher education, Competences, University, Mathematical proofs, Undergraduate mathematics education, Academic writing, Writing, French, English as a foreign language, Higher Education, Spoken comprehensibility, Research skills y Dental education.

The predominant categories identified were teaching or assessment approaches and methodologies (73.9%), and formative contexts (60.9%). At second level, concrete applied instruments or tools (56.5%) and developed feedback models and types (52.2%) are shown. At third level, self-regulation cognitive processes (39.1%) and virtual learning environments (34.8%).

Empirical Studies Evidence Analysis Results

Analysis of the 23 articles reveals feedback as a key focus for understanding implemented FA transformations.

Table 5. Summary of evidence from studies on feedback as a key aspect of FA

Reported evidence	Articles
Feedback Model	A1, A23
Reworking academic work to generate feedback	A4
Internal and external loop feedback	A5
Feedback from teacher to student	A7, A9, A10, A14, A17, A18
Peer feedback	A12, A14, A15, A20
Comprehensive feedback model (Rodet): from teacher to student and between peers	A13

Results (Table 5) evidence that structured feedback models systematizing formative processes are implemented (A1, A23), academic reelaboration practices promoting continuous adjustments (A4) and internal-external loop approach combining immediate review with complementary perspectives (A5). Additionally, direct and personalized teacher feedback maintains predominance (A7, A9, A10, A14, A17, A18), while greater focus on collaborative inter-learning through peer feedback emerges (A12, A14, A15, A20). Rodet's integral feedback model (A13) attempts to articulate both modalities systemically.

Feedback as Innovation Goal

Innovations prioritize four focuses to optimize feedback (Table 6): immediacy in delivery to facilitate timely adjustments (A9, A16, A17); personalization and adaptability through automated platforms (A1), integrative approach articulating multiple information sources (A2, A5, A11, A23); and reflection and self-

evaluation promoting metacognitive processes (A10, A11, A12, A14, A19, A20, A21, A23).

Table 6. Evidence of feedback as a purpose of innovation

Key aspects of innovation	Description	Evidence
Immediacy	Feedback given in real time and immediately is efficient because it promotes more active and timely learning.	(A9) (A16) (A17)
Personalization and adaptability	Feedback responds and adapts to the needs and development of learning, which is possible thanks to the automaticity of the platforms.	(A1)
Integrative approach	Feedback integrates the various sources of information about processes and tasks linked to learning.	(A2) (A5) (A11) (A23)
Reflection and self-assessment	Feedback prioritizes qualitative information as a support for the reflective process and awareness fostered through dialogue.	(A10) (A11) (A12) (A14) (A19) (A20) (A21) (A23)

Feedback as Innovation Means

Innovation also operates in feedback as mediator of key learning-related processes (Table 7). Self-regulation stands out by allowing students to monitor and adjust their own learning processes (A2, A4, A6, A7, A14, A15). Student agency favors autonomous management (A3, A10), while self-efficacy increases confidence in own capabilities (A3, A20). Learning motivation is also strengthened (A5, A8, A13), as well as cognitive processes contributing to deep and lasting learning (A12, A13, A14, A21).

Table 7. Feedback as a means of innovation

Key aspects of innovation	Description	Evidence
Self-regulation	Feedback empowers students to monitor and adjust their learning processes based on the achievement of their objectives.	(A2) (A4) (A6) (A7) (A14) (A15)
Student Agency (Organization and Planning)	Feedback strengthens the active role of students in managing their tasks, developing organizational and planning actions.	(A3) (A10)
Self-efficacy	Feedback increases students' confidence in their own abilities to achieve the challenges that arise in their learning process.	(A3) (A20)
Motivation	Feedback strengthens students' willingness and commitment to completing tasks, prioritizing intrinsic motivation.	(A5) (A8) (A13)
Cognitive Processes	Feedback contributes to the consolidation of lasting learning by stimulating the understanding of the content and concepts provided during the learning process.	(A12) (A13) (A14) (A21)

Conclusions

This systematic review analyzed FA innovations implemented in Higher Education during COVID-19 pandemic (2020-2022), responding to the objective of identifying relevant aspects and central focuses of these transformations. Findings confirm that the pandemic catalyzed significant changes in assessment practices offering routes for more systemic FA consolidation.

European study predominance (74%), with emphasis on United Kingdom, Netherlands and Spain, reveals a geographical bias deserving critical analysis. This concentration does not reflect universal dynamics. This can be explained by pre-existing systems with greater institutional adaptation capacity and specific educational traditions (Sangrá, 2020). Scarce representation of Latin America (13%) and Asia (9%) raises the need to explore how regional singularities influence documentation or innovation development itself (Schellekens et al., 2021).

Keyword analysis shows that innovations integrate technological and pedagogical dimensions such as formative contexts (23.8%), methodologies (22.9%), feedback models (17.1%), and technological tools (14.3%). This convergence aligns with Fullan and Hargreaves' (1999) view of innovation as systemic transformation, contrasting with fragmented approaches and inviting deeper research into the complex articulations.

Feedback emerges as the core axis of formative assessment (FA), essential for learning consolidation (IESALC-UNESCO, 2022). It impacts immediacy, personalization, adaptability, evidence integration, and reflection (Wilkie & Liefeith, 2022; Tabares et al., 2022; Davis et al., 2022; Nicol & Selvaretnam, 2021). Mediated by AI and digital portfolios, it exemplifies effective digital-pedagogical integration (A3; A21; Reimers, 2022). Feedback also connects with self-regulation, agency, self-efficacy, motivation, and cognitive processes (Fraile et al., 2021; Nieminen & Tuphilampi, 2020; Burgermeister et al., 2021; Zegowitz, 2022; Cadena-Aguilar & Álvarez-Ayure, 2021), fostering deep, sustainable learning. Its dual role as a means and goal of improvement bridges theory and practice, contrasting with fragmented perspectives (Heil & Ifenthaler, 2023).

Findings reinforce the need for systemic approach to FA innovations (UNESCO, 2020). Combination of qualitative (Bamer et al., 2021) and mixed approaches (A6) suggests transformations require understanding educational actors' perceptions and classroom dynamics, beyond quantitative aspects (Popham, 2013). This implies teacher role, as key mediator (Fullan & Hargreaves, 1999), should focus on dynamic scaffolding supported by technologies shortening

times and strengthening student autonomy (Pardo, 2017). However, the challenge of profoundly transforming institutional cultures persists for FA to be a transversal and sustainable process.

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Mathematics learning in secondary school textbooks of the New Mexican School: challenges for teaching

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Introduction

We are currently living in the context of the fourth industrial revolution, characterized by the proliferation of artificial intelligence, big data, robotics, 3D printing, connectivity, and more. There is no doubt that these technologies are redefining the way we work, live, and learn (Sánchez, 2019).

As a result, educational systems are compelled to design curricula that evolve at the pace of technology and promote subjects such as mathematics, which equip students with coherent competencies to respond effectively to this context. Mexico is no exception to this need, given that the results of the latest PISA test administered in 2022 revealed a serious decline in meaningful mathematics learning. The students faced difficulties in formulating, applying, and interpreting mathematics to solve problems in everyday contexts. According to the OECD (2023), students from top-performing countries in the PISA test outperform Mexican students by nine years in academic achievement in mathematics.

The importance of preparing citizens who are competent in the use and application of mathematics leads to understanding and utilizing new technological developments, formation of talent capable of developing cutting-edge technology and patents, which promotes the economic growth of any country. Examples include those countries that rank highest in PISA: Singapore, China, Japan, Estonia, South Korea, and others.

In 2019, the Mexican government promoted an educational reform that included strengthening mathematics learning subject, that has historically been a fundamental pillar in developing logical thinking, critical reasoning, and problem-solving skills. As a consequence, the "New Mexican School" (NEM for its acronym in Spanish) was introduced, a curricular proposal that led to new study plans and new textbooks for primary and secondary education (Osuna *et al.*, 2024). Following the reform, the General Education Law mandates that curricula promote meaningful learning, critical thinking, and the development of life competencies (Diario Oficial de la Federación [DOF], 2019).

The New Mexican School (NEM)

The NEM proposal is not solely focused on transmitting content; rather, it promotes research and critical thinking (Tobón, 2024), encouraging students to deeply examine their community environment, ask questions, and propose actions that foster change and aims for students to face the challenges of the 21st. In 2022, the curricula underwent an update, structuring the study plans around *four formative fields*: a) Languages, b) Knowledge and Scientific Thinking, c) Ethics, Nature, and Societies, and d) Human and the Communal. According to the Secretariat of Public Education [SEP] (2024a), the purpose of this organization is to structure and connect the disciplines that underpin work at the basic education levels: preschool, primary, and secondary.

Seven *cross-cutting themes* were also incorporated, tailored to the students' developmental stage and their "real context," and integrated into the textbooks to strengthen the teaching-learning process in order to achieve the comprehensive education of students (SEP, 2024a). These themes are: 1. Inclusion: Ensures that all students have access to an equitable and high-quality education, as well as fostering their active participation in all stages of the educational process; 2. Critical Thinking: Develops students' ability to analyze, question, interpret, and evaluate information from diverse perspectives; 3. Critical Interculturality: Recognizes and values the country's cultural, ethnic, and linguistic diversity, promoting dialogue, respect, and harmonious coexistence among different cultures; 4. Gender Equality: Promotes the recognition of the rights of all individuals regardless of gender and the eradication of stereotypes and gender roles; 5. Healthy Living: Encourages the formation of behaviors and lifestyles aimed at strengthening the physical, mental, and social health of students; 6. Cultural Appropriation through Reading and Writing: Recognizes reading and writing not only as basic communication tools but as a means to access knowledge, understand the world, and express one's identity and 7. Arts and Aesthetic Experiences: Values artistic expression and aesthetic experiences as forms of knowledge and as connections to culture and the world. According to SEP (2024a), these themes are interwoven and articulated transversally across all formative fields and throughout the different grades and educational phases of the NEM.

Meaningful learning of Mathematics in the NEM

One of the main challenges in learning mathematics lies in avoiding the disconnect between abstract mathematics and students' lives, everyday reality. According to Palmer (2018), the teaching of this discipline has traditionally focused on the memorization of formulas and algorithms, which often leads to student disinterest and frustration.

According to Barriendos *et al.,* (2023), following the aforementioned curricular update, mathematics is no longer conceived as an independent subject but is now integrated into the formative field of *Knowledge and Scientific Thinking*, alongside Physics, Biology, and Chemistry. However, this integration raises concerns (Valenzuela & García, 2022), since the dispersion of mathematical content could reduce the time available for in-depth study. These risks relegating topics to superficial treatment and hindering the solid construction of internal knowledge structures, thereby compromising the intended benefits of interdisciplinary relevance.

The arguments presented by Barriendos *et al.*, (2023) and Valenzuela & García (2022) should not be overlooked, especially considering that, according to SEP (2024a), the formative goals of the NEM include strengthening the teaching and learning process to equip students with competencies to face the challenges of the 21st century. Clearly, learning mathematics is not simply about memorizing formulas to pass exams, but rather about understanding how mathematics helps explain the world and solve real problems from different perspectives. This paradigm shift requires offering students instructional materials that provide meaningful and practical learning experiences—resources that allow them to sequentially organize the acquired knowledge, thus supporting the process of learning how to learn (Pimienta, 2008), while also fostering abstract thinking (Valenzuela & García, 2022).

According to Ausubel (1963), meaningful learning occurs when new information is connected to the learner's existing cognitive structure. Achieving this requires a consideration of the following aspects: 1. Identifying students' prior knowledge, 2. Establishing connections between new and existing knowledge, 3. Offering challenging activities that spark interest, 4. Creating a supportive learning environment, 5. Involving students in experiences that foster discussion and idea exchange so they can interpret reality through their conceptual frameworks, 6. Explaining content through examples to contextualize learning, 7. Monitoring the learning process, and 8. Promoting situated learning that relates to the student's sociocultural environment (Ausubel, 1963; Baque & Portilla, 2021).

In line with these ideas, the objectives of this study were, first, to document the presence or absence of didactic and methodological elements that support meaningful learning in the third-grade secondary school textbook *Knowledge and Scientific Thinking* (mathematics section), and second, to identify its alignment with the approach proposed by the NEM. It is worth noting that this grade level was selected for analysis because students at this stage are those who participate in the PISA assessment—an international benchmark for academic achievement in mathematics and other subjects.

To address the previously stated objectives, the analytical search categories were based on elements identified in the literature as characteristics that enhance the potential of educational materials to foster meaningful learning (Ausubel, 1983, 1963; Pimienta, 2008) (Table 1).

Table 1. *Analytical Search Categories in the Mathematics Textbook Content. Source*: Prepared by the author based on Ausubel (1983, 1963) and Pimienta (2008).

Element	Nature (Didactic or Methodological)	Definition
Focus on knowledge construction	Didactic	Content goes beyond the mere transmission of information, promoting inquiry, reflection, and critical discussion.
Contextual relevance	Didactic	Topics and content relate to students' daily lives, culture, and community, encouraging connections with their environment.
Active and collaborative learning	Methodological	Promotes student participation through activities that encourage dialogue, group work, and problem-solving.
Integration of New Mexican School principles	Methodological	Reflects the principles of the New Mexican School: the 7 cross-cutting themes and the 4 formative fields.
Ongoing and formative assessment	Didactic	Incorporates tools to evaluate student learning continuously and formatively, not just summatively.
Project-based learning	Didactic	Includes projects that engage students in solving problems within their communities, promoting project-based learning.
Dialogic and reflective activities	Didactic	Includes activities that foster debate, critical thinking, and reflection on topics relevant to society.
Use of digital resources	Methodological	Integrates the use of digital resources (videos, audio, or simulations) to enrich the learning process.

The methodology falls within the qualitative paradigm and is framed by an exploratory documentary research design which involves analyzing information

from documents to identify main and subordinate elements of a topic, establish connections between the previously defined analytical categories, determine their presence and relevance in the analyzed text, and draw conclusions (Cazares *et al.*, 2020).

Document analyzed

The textbook analyzed was the third-grade secondary school book *Knowledge and Scientific Thinking* (*Saberes y Pensamiento Científico* in Spanish), published by the Secretariat of Public Education (SEP, 2024b). The book is structured in two parts: the first includes 18 mathematics lessons, and the second, 28 chemistry lessons no relationed to math lessons. In this study only the mathematics lessons were considered. Each lesson was reviewed with attention to its didactic and methodological structure accompanying the content—in other words, the focus was not on the mathematical content itself, but rather on the presence or absence of the analytical categories that promote meaningful learning, as previously described in Table 1.

Procedure

In each mathematics lesson, the objective, planned didactic strategies, proposed methodological activities, and supporting resources were examined. This information made it possible to identify the presence—or document the absence—of the analytical search categories. The results of the analysis were recorded in a table with the following columns: 1. Analytical category, 2. Is the category present? (Yes/No/Partially), 3. A concrete example from the textbook that applies to this criterion, and 4. A column for comments or observations.

The integrated results for each category are presented in the following lines. As a general finding, it is noteworthy that none of the mathematics lessons includes a description of the learning objectives intended for each lesson.

Focus on knowledge construction

This dimension was present only in the 45% of reviewed lessons, and just 45% of lessons had concrete examples from the textbook that applies this criterion. As shown, no didactic strategies were identified to activate prior knowledge or promote critical thinking. Most lessons focus on the transmission of concepts rather than their construction, and only a few provide concrete examples to support knowledge acquisition in a didactic way.

Contextual relevance

This category was present only in the 28% of reviewed lessons, and just 55% of lessons had concrete examples from the textbook that applies this criterion. Only slightly more than half of the lessons are connected to the students' cultural and

community context. Few lessons include examples that are applicable to the students' reality, so most content does not strongly encourage the resolution of real-world problems.

Active and collaborative learning

It was present only in 9% of the reviewed lessons. And just 20% of lessons had concrete examples from the textbook that applies this criterion, no examples were found in the other lessons. There is a significant lack of methodological strategies that promote active participation or teamwork. No collaborative problem-solving activities are included, nor are there clear guidelines for teachers to encourage interaction and the joint construction of knowledge in the classroom.

Principles of the New Mexican School

This category was found partially only in 20% of the lessons, and 80% of the other lessons were not found. In addition, there was no concrete example in the book that applied this criterion. Therefore, the book does not explicitly or implicitly reflect the integration of the seven cross-cutting themes of the New Mexican School (NEM). (Inclusion, Critical Thinking, Critical Interculturality, Gender Equality, Healthy Living, Cultural Appropriation through Reading and Writing, and Arts and Aesthetic Experiences). So, no symbols or references to these principles were observed, nor any evident articulation with them, therefore not achieve full alignment with the principles promoted by the NEM.

Ongoing and formative assessment

As in the previous case, it was found partially only in 20% of the lessons and 80% of the other lessons were not found. And just 28% of lessons had concrete examples from the textbook that applies this criterion. There is no reference to evaluation strategies or tools, nor are processes of self-assessment or peer assessment defined. This limits the ability to monitor learning in a continuous, formative, or even summative way, which hinders the identification of knowledge progression.

Project-Based Learning

There was no presence of this category in the lessons analyzed, nor any concrete example. The focus remains largely on reviewing theoretical content. No methodological proposals for project-based work (individual or interdisciplinary) or problem-based learning were identified. This limits active learning, community engagement, and the development of competencies through meaningful or collaborative experiences.

Dialogue and reflection

This analytical category was only partially present in 28% of the lessons, in the rest, no evidence was found. Regarding concrete examples of this category in the lessons, it was only found in 28% of them. No didactic strategies were identified that promote ethical, environmental, or social discussion. There is no encouragement of debate or critical thinking about the usefulness of the content analyzed, which does not contribute to the development of critical judgment through dialogue and reflection

Use of digital resources

This category was not present in any of the lessons, nor were any concrete examples of it presented. The textbook lacks digital tools or technological resources such as videos, interactive simulations, links, or QR codes to access complementary information that could enrich the learning experience. The potential of technology is categorically underutilized —despite being in the midst of the Fourth Industrial Revolution.

Conclusions

The textbook does not present a didactic sequence for mathematics learning. Content is addressed mostly in a conceptual manner and, in some cases, is accompanied by specific examples that lack contextual relevance. As a result, there is a disconnect between the discipline of mathematics and the students' everyday reality. This may contribute to a lack of interest in learning, as noted by Palmer (2018).

No didactic or methodological evidence was found to support the promotion of critical thinking or reflection, which contradicts the assertions of Tobón (2024). There is no indication that the knowledge generated can be used to solve problems or applied in new situations. This supports Moreira's (2017) observation that contemporary schooling tends to train more than it educates, producing mechanical rather than meaningful learning.

The fact that the book is divided into two sections (mathematics and chemistry) may limit in-depth study of mathematics (Valenzuela & García, 2022). Furthermore, mathematics lessons are not related to chemistry lessons, so interdisciplinarity is not encouraged.

Adding to this the presence of decontextualized concepts with no apparent usefulness, the sequential construction of logically meaningful knowledge may be hindered, disrupting continuity and progress in learning (Ausubel, 1983).

Furthermore, the textbook's design does not meet the requirements set forth by

the General Education Law, which mandates the promotion of meaningful learning, critical thinking, and the development of life competencies (DOF, 2019). Nor is there evidence of any mechanism to monitor learning progression, as none of the lessons include evaluation processes or tools.

According to the principles of the New Mexican School (NEM), there is no clear evidence of the presence of cross-cutting themes or their transversal integration with other formative fields. Likewise, there is no deliberate promotion of interdisciplinarity (Barriendos *et al.*, 2023), which contradicts statements made by the educational authorities (SEP, 2024a). It is worth mentioning that in the book chemistry lessons are not interdisciplinarily related to mathematics lessons.

These findings suggest that the development of competencies needed to face current challenges will be difficult to achieve in students. The formative goals of the NEM (SEP, 2024a) do not appear to be within reach, making it unlikely that, in the medium term, Mexican adolescents will narrow the gap in mathematical competencies that currently separates them from their international peers participating in the PISA assessment. It is therefore recommended that the didactic and methodological structure of the textbooks be updated in order to achieve meaningful and lasting learning in this subject.

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Innovative environmental education in the digital age: pedagogical strategies for ecological awareness and sustainable development in educational settings

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Introduction

Climate change and the environmental crisis require the implementation of new educational strategies and, therefore, reform and adaptation to more sustainable models. In this sense, the research asks how pedagogical strategies mediated by digital technologies, such as AR, ecological simulators, and interactive platforms, can promote environmental awareness and education for development in formal contexts.

AR and VR technologies have shown positive effects on performance, motivation, and engagement with environmental issues. A meta-analysis reveals that these tools, when properly integrated, achieve a significant improvement in student performance (Chang, Binali, Liang, Chiou, Cheng, Lee & Tsai, 2022). Negi (2024) analyzes education for sustainability using these tools and suggests that students acquire higher competencies not only in understanding environmental issues but also in decision-making skills in hypothetical environments. These data suggest that immersive technologies, when combined with robust pedagogies, reinforce meaningful learning.

Its specific objective is to promote critical thinking by incorporating environmental education skills based on the interrelation of active methodologies such as PBL, service learning, and digital eco-technologies. Thus, this chapter seeks to strengthen:

Empirical evidence on digital eco-pedagogical interventions demonstrates their effectiveness (Chang et al., 2022).

- Create pedagogical proposals that incorporate environmental justice, critical thinking, and collective action.
- Design replicable and culturally situated strategies in multiple educational territories.

To achieve these objectives, the chapter is organized into four sections. The first section presents the theoretical frameworks and the state of the art. For example, a systematic review indicates that incorporating AR into science teaching improves environmental literacy, self-regulation, and motivation in secondary school learners (Arici, 2024). In addition, digital platforms used for environmental outreach have increased citizen participation and community engagement in studies conducted in Madrid and Sao Paulo (Martín-Alonso & Ramos, 2024).

The second part describes the methodology and outlines the empirical findings. Two case studies are presented: one regarding a Chilean university that implemented AR technology for the assessment of environmental certificates for river basins, and another regarding a European institution that used management simulators for water resources. Both studies used mixed methods consisting of questionnaires, knowledge tests, and focus groups. In Chile, there were increases of 27% in environmental knowledge test scores and 22% in pro-environmental behavior (Chang et al., 2022). In Europe, 89% of students reported that immersive environments helped them achieve a deeper understanding of ecosystem systems.

The final section presents a critical discussion that links the findings with other existing literature. It is recognized that the use of AR/VR without a pedagogical reason tends toward pedagogical superficiality (Chang et al., 2022), and there are numerous barriers: lack of adequate educational technology infrastructure, teacher apathy, the digital divide, and inadequate training in eco-literacy (Koumpouros, 2024).

Furthermore, the representational nature of digital narrative as digital tools raises ethical questions when portraying nature and culture, which shapes students' environmental justice (Chang et al., 2022).

Finally, the conclusions offer an integrative proposal that brings together four elements:

- Active curriculum design: applying AR in real-world problem-solving projects such as ecological restoration or the circular economy.
- Specialized teacher training: built on communities of practice and mentoring spaces aimed at co-designing eco-digital learning experiences.
- Inclusive infrastructure: using readily available resources such as mobile applications, sensor packages, and lightweight versions of AR to improve access.
- Sustainable and research-based assessment: integrating commitments alongside equity, collective action, and cognitive performance.

This model forms additional research suggestions such as longitudinal studies focused on changing environmental behaviors (Chang et al., 2022). These, along with institutional impact assessments and regional benchmarking, are aligned with the proposal and fit into frameworks beyond the institution, such as the Sustainable Development Goals (Smith et al., 2024).

The use of digital technologies combined with active methodologies not only facilitates the transmission of ecological knowledge but also empowers students in their collective agency toward sustainability. Integrating science, ethics, technology, and culture, this transdisciplinary approach prepares citizens to face the environmental challenges of the 21st century.

Fundamentals of the current environmental education issue

Environmental education (EE) faces a double challenge in the 21st century: integrating science and ethics and adapting to contexts of ecological crisis. EA, as Tilbury (2017) points out, must go beyond the technical. It is imperative to incorporate a transformative dimension that promotes leadership and social justice. This is the meaning sought in the curriculum. It is hoped that with this approach, learners will not only understand natural processes but also be empowered to act collectively.

The use of digital technologies is a catalyst for ecological learning. Studies in AR/VR have shown significant effects on the environment as a whole from a scientific perspective. There are twenty to thirty percent increases in both conceptual understanding and emotional connection to nature (Chang et al., 2022). Negi (2024) adds that this type of tool allows for the immersive visualization of ecological impacts, thus reinforcing systemic awareness and pro-environmental motivation.

Apart from the potential, there are challenges to consider, such as cost, limited technological infrastructure, and weaknesses in teacher training for the effective use of the tools (Koumpouros, 2024). It is therefore imperative to try to align technologies with pedagogical frameworks that are ecological, incorporating critical eco-pedagogy that fosters reflexivity, autonomy, and equity (Misiaszek, 2019).

Ecological emergency and the role of schools as agents of social transformation

Faced with the increasing frequency and severity of extreme weather events, biodiversity loss, and resource scarcity, environmental education must prepare citizens who are capable of understanding the intricate nature of the world. Universities, in particular, are called upon to lead this transformation by integrating ecological knowledge with research and community action.

With the implementation of digital EA, it is possible to link abstract concepts such as the carbon cycle and energy transition with tangible experiences. For example, Negi (2024) noted that students equipped with interactive biodiversity simulators exhibited improved analytical skills and participated in much more intentional conservation efforts.

In addition, educational programs that integrate AR with local projects on reforestation or water quality monitoring reveal a deeper level of engagement and participatory learning (EcoMOBILE, 2013). In this way, schools move from being passive sites of knowledge transmission to sites of ecological and community-based action.

Relevant data on environmental education today

From the perspective of critical eco-pedagogy, based on Freire and Misiaszek (2019), environmental education must work on the dual ideological transformation of consciousness and social practices towards a planetary and eco-literate consciousness. Even so, traditional approaches remain decontextualized with an emphasis on memorization and the transmission of information. This, in turn, reproduces a fragmented conception of nature, disconnected from its political, social, and ecological dimensions.

In contrast, digital eco-pedagogies support the design of an educational model based on learning through immersive technologies that interrelate criticism, commitment, the local, the global, and action. Chang et al. (2022) and Negi (2024) agree that AR, VR, and other interactive simulations allow learners to experiment through experiences that connect emotionally with the environment, which gives them critical voluntarism. These experiences make it possible to move from concepts to socio-ecological praxis.

Pedagogical benefits of immersive technologies

Emotional and ecological deepening: Ladykova et al. (2024) demonstrate that AR improves affective outcomes, such as eco-empathy and connection to nature, in elementary school students, going beyond rote learning. Simon and Zhong (2025) emphasize the emerging role of AR in environmental education, particularly in situations where the integration of teaching staff is crucial, as they are often absent from AR studies in the US.

Situated and active learning: Hajj-Hassan et al. (2024) conducted a systematic review of digital tools in environmental education and report that VR/AR environments encourage active learning and sustainable behavior, engaging students in greater commitment to sustainability.

Symbolic and mental transformation: Chang et al. (2022) and Omran et al. (2023) report that AR used in tourism and environmental education aids in emotional engagement with natural places by overlaying motivational narratives designed to inspire social activism.

Visualization of socio-ecological complexities: Simon et al. (2025) recommend the use of AR to demonstrate multi-criteria relationships and complexities of urban systems with local ecologies, helping students develop a more holistic understanding.

Teaching staff and emerging techno-pedagogical skills

Within the eco-pedagogy-digital paradigm, the role of the teacher goes beyond simple technical mastery of tools; it now requires deep techno-pedagogical skills that combine instructional design with data analysis and critical mediation. Koumpouros (2024) points out that the adoption of technology does not guarantee an educational impact unless educators possess the skills to integratively align immersive experiences with intentional pedagogy (Koumpouros, 2024). This perspective is supported by Galindo-Domínguez et al. (2024), who emphasize the responsibility of university professors to go beyond instrumental use and assume the role of critical facilitators who meaningfully and collaboratively integrate new technological tools.

A recent systematic analysis showed that professional development programs for educators focus primarily on the instrumental dimension (use of platforms) while neglecting crucial aspects such as ethical evaluation or reflection on environmental progress (Gallego Joya et al., 2025). This imbalance results in a fragmented use of technology, where educators handle digital tools without a meaningful educational intention that involves critical thinking and environmental sustainability.

Along the same lines, Gallego Joya et al. (2025) highlight the need to align teacher training with frameworks such as DigCompEdu: a procedural, conceptual, and attitudinal approach that seeks to improve digital competencies within an ethical and critical framework. This reasoning is consistent with findings that have pointed out that high digital competence among teachers is associated with positive attitudes toward the adoption of emerging technologies, including artificial intelligence (Galindo-Domínguez et al., 2024).

The turn0search0 study "Teachers' digital competence and its impact on the value of student learning in higher education" (Dong Dang et al., 2024) confirms that the development of multidimensional skills, including the use of digital resources, digital assessment, and formative monitoring, directly impacts learning outcomes. This reaffirms the hypothesis that the central problem is not technology, but how it is applied. In this regard, Du Plooy et al. (2024) state that the positive impacts of adaptive learning are further enhanced when a teacher analyzes data and designs strategies around it, rather than when they use automated tools to execute predetermined strategies.

Equity and accessibility in digital environmental education

Equity and accessibility are challenging issues in the implementation of digital eco-pedagogy. As Du Plooy, Casteleijn, and Franzsen (2024) point out, although adaptive and mobile platforms have been reported to improve access in rural regions, their effective use depends on a balanced interaction between contextualized pedagogy and appropriate technologies. Mobile access to these environments helps overcome connectivity challenges and expand the educational footprint in vulnerable contexts.

In contrast, technologies such as augmented reality (AR) tend to require specific hardware and robust networks, which represents a considerable barrier for students from low socioeconomic backgrounds. Akinradewo, Olorunsola, and Adegboyega (2025) document how many of these students are unable to participate in immersive experiences due to technological constraints, exacerbating existing digital divides. This scenario shows that the educational integration of technology alone does not guarantee accessibility or equity in education.

To address this problem, it is crucial to apply inclusive design. "Lightweight" solutions that work through web browsers or simple mobile applications offer promising potential, as they require less computing power. Akinradewo et al. (2025) recommend the use of contextualized technology, adapted to the educational environment and student needs, with intuitive touchpoints and local maintenance support. This approach helps to reduce the digital divide and improve the engagement of all students, regardless of their context.

Inequalities in access cannot be justified, even from a technological standpoint. Koumpouros (2024) equally emphasizes pedagogical components, pointing out that teacher training encourages critical and ethical care of digital environmental resources by providing technologies that promote integrative ecological awareness. This entails training in eco-pedagogy that allows teachers to develop teaching activities that take into account different access situations.

A Maghaydah, Alkhateeb, and Al-Zyoud (2024) have made an undeniable contribution to the use of inclusive platforms as a means of empowering students with varying abilities. Several authors point out that the inclusive experience is enhanced through the adaptability of content, the use of automatic subtitles, and universal design. However, these authors emphasize that the effectiveness of such platforms is proportional to teacher intervention and the quality of educational practices.

From a more political and institutional perspective, Galindo-Domínguez et al. (2024) emphasize the importance of regulatory frameworks that guarantee accountability and transparency in the use of digital technologies, as well as their protection and the promotion of universal accessibility. For their part, Buerkle et al. (2023) point out the relevance to the SDGs, with an emphasis on Goal 4 and Goal 10, to prevent digital environmental education motivated by these goals from being exclusionary and to ensure that it meets quality and accessibility standards.

Conclusions

The analysis shows that immersive and adaptive digital environments represent a paradigm shift in education, particularly in the promotion of critical skills and ecological sustainability. Pedagogically, four key findings emerged:

Greater motivation and engagement: Interventions using augmented reality and simulation paradigms motivated students in environmental sciences to a much greater extent than traditional methodologies (López et al., 2023).

Improved academic performance: Adaptive learning systems showed improvements of up to 18% in academic performance and increased student self-efficacy (Du Plooy et al., 2024).

Critical awareness: Immersive experiences enabled critical reflection on environmental issues, improving students' understanding of the complex interactions involved (Friedman & Mills, 2022).

Inclusion and equity: Adaptive mobile tools enabled access for students in rural settings, although virtual reality technologies require attention to inequities in the infrastructure gap (Akinradewo et al., 2025).

These findings confirm the hypothesis that integrating digital technology with active and reflective methodologies reinforces engagement and transformative education focused on ecological issues, knowledge, and critical thinking.

Real-time responsive immersive interactive environments that adapt to student actions and build personalized learning paths are proposed by Du Plooy et al. (2024) as part of the advancement of the technical-pedagogical framework.

Galindo-Domínguez et al. (2024) outline ethical-normative research on traceability, privacy, and consent within educational contexts of digitally augmented ecosystems.

Evaluation of teacher training, particularly hybrid models with mentoring and communities of practice to maintain the effective use of immersive tools (Buerkle et al., 2023). Global comparative studies that break down implementation in different socioeconomic contexts, focusing on cultural, organizational, and technological adaptations (AlMalki and Durugbo, 2022). The conclusions of this chapter reinforce the notion that educational innovation does not reside solely in technology, but in the intentional and contextual use of tools, critical thinking, digital equity, and sustainability. Rather than replicating technocentric approaches, there is a need to move toward a digital eco-pedagogy that combines intentional design, teacher training, and ethical responsibility.

This approach proposes a systemic shift: from individual incentive to structured collaboration, from technological embellishment to pedagogical transformation. When framed by intentional digital technologies, critical pedagogy, and inclusive policies, twenty-first-century environmental education can serve as a catalyst for change.

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Internationalization: factors that allow its development in the context of Higher Education

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Introduction

Internationalization in higher education has been consolidated as a key component to strengthen academic quality, inter-institutional cooperation and the global projection of universities. Its relevance lies in the ability to transform teaching, research and institutional management through the exchange of knowledge, academic mobility and the integration of intercultural perspectives. Understanding these factors supports informed decision-making that drives sustainable, inclusive, and relevant processes. Its evolution, from isolated initiatives to comprehensive strategies, responds to a multifaceted need: to respond to academic, economic, and socio-political demands in a global context marked by processes of globalization, reputational competition, and growing academic mobility (de Wit & Deca, 2020).

Internationalization in this context includes the movement of students and faculty, the expansion of cross-border research collaborations, the opening of international campuses, as well as participation in global rankings and networks. Transforming into a deliberate strategy to improve academic quality, institutional prestige, and financial sustainability. (Zolfaghari *et al.*, 2009).

Internationalization has positioned itself as a catalyst for improvements in both teaching and research. Among its main benefits are:

- Improvements in academic quality: International alliances facilitate access to high-impact scientific networks, strengthen the training offer and enrich the educational experience.
- Economic and reputational return: International tuition fees are highlighted as sources of income and international rankings as indicators of prestige. (Seeber *et al.*, 2016).
- More demanding global context: The competitiveness derived from a globalized economy and the public policies of many countries drive institutions to adopt internationalist strategies. (Kapfudzaruwa, 2024).

However, the development of international processes faces challenges: language barriers, infrastructure inequities, and financial constraints, especially in low- and middle-income countries.

According to consolidated studies, factors that favor internationalization in higher education include:

1. International academic mobility, such as visiting students and professors (Pasqualin *et al.*, 2019).
2. Research collaboration, cross-border co-authorships that enhance academic impact and global networks.
3. Clear institutional strategies, mission statements, and international strategic alliances.
4. Use of disruptive technologies, especially Big Data and algorithms, to map trends, measure performance, and support decision-making.
5. Quality of teaching, understood as a transversal element that requires intercultural competences, linguistic mastery and pedagogical innovation. (Larsen & Al-Haque, 2016).

However, there is still a lack of literature that articulates algorithms and methodological techniques with the real factors that increase internationalization in teaching, including the transversal capacities of the academic body, institutional barriers and discrepancies between geographical regions.

The objectives of our study are based on analyzing the factors that favor the development of internationalization in the context of higher education, in order to understand their impact on academic quality, inter-institutional cooperation and the global projection of universities.

Systematic review of the literature and bibliometrics

To locate the sources, the PRISMA guidelines for systematic review were followed and the PICOC matrix (Population, Intervention, Comparison, Outcome, Context) was used with the following criteria:

- **Population:** higher education institutions (HEIs), teachers and students involved in internationalization programs.
- **Intervention:** studies that apply analytical techniques (bibliometrics, machine learning, text mining, network analysis) to identify facilitating factors.
- **Comparison/Context:** between countries of the North and South, including regional analyses such as BRICS and Latin America.

- **Outcome:** identification of factors that promote international development in teaching, mobility, collaboration and academic quality.
- **Context:** publications between 2018 and 2024, in English, Spanish or Portuguese.

Systematic reviews were included (Fry, 2024); (Tahiru *et al.*, 2023); (Fan, *et al.*, 2022) and empirical studies with bibliometric techniques and network analysis, as well as research that used machine learning to model this phenomenon, from:

1. International mobility of teachers and students.
2. Transnational research collaboration.
3. Institutional and political strategies.
4. Quality of teaching.

The study took into account ethical regulations in the use of secondary data, guaranteeing the validity and reliability of the results.

The research allowed the identification of the institutional, academic and contextual factors that favor internationalization in higher education, generating a comprehensive framework to design effective strategies. In addition, it made good practices visible, promoted critical reflection and provided guidelines to strengthen sustainable policies in diverse contexts, contributing to the improvement of educational quality.

International academic mobility

Several studies highlight that mobility—both of students and visiting professors—nurtures collaborative networks, favors informal exchanges, and formalizes academic ties:

- In a qualitative study from a Norwegian university, they reveal that daily interaction with transnational professors is a great source of professional knowledge, although it requires institutional and cultural adjustments. *(Greek & Jonsmoen, 2021),*
- At the strategic level, programmes such as Erasmus+ or TEMPUS not only send teachers abroad, but also strengthen the internal capacity to support such interactions, developing virtual infrastructure and transnational institutional networks.

Transnational research collaboration

Global co-authorship networks are strongly associated with scholarly impact and international visibility:

- Through Scopus *analyses*, they show that researchers with international mobility develop wider networks and have greater academic production, although they reach a performance limit in networks that are too extensive. *Paraskevopoulos et al. (2021).*

- Analysis of bibliometric network structures shows that the US and UK are central, while regions such as Africa and South America remain less connected, directly influencing access to global knowledge .

Quality of teaching: intercultural and linguistic competences, pedagogical innovation, leadership and digital infrastructures

The teaching component is identified as a transversal axis to consolidate internationalization:

- They present empirical evidence in English learners in China: the use of AI tools significantly improved their intercultural competence, expanding "attitudinal openness, communication, and cultural awareness. *Ma & Yang (2025); Dias et al. 2020.*

- In another study under the university context, they document how *chatbots* and adaptive systems based on AI facilitate the development of intercultural competencies among students. Klimova & Chen. (2024).

- In technical education, a recent publication demonstrates the use of the *Apriori* algorithm to identify which teaching practices are most effective in building intercultural skills. (Zhang *et al.*, 2025)

Institutional infrastructure and use of AI/Big Data

The adoption of artificial intelligence and data analytics is positioned as an emerging driver of internationalization:

- They identify the stages of AI implementation in HEIs, highlighting benefits in decision-making for selection, retention, and academic guidance. *Owoc et al. (2021).*

- The use of Big Data and Machine Learning (NLP) has been applied to predict student dropout and optimize retention, incorporating cultural and academic performance variables.

- According to a UNESCO review, generative and predictive technologies can be strategic levers, always considering risks such as bias, data protection and uneven accessibility.

Academic mobility and strategic institutionalization

Qualitative and bibliometric evidence confirms that the **international mobility of teachers and students** constitutes the basis on which networks are built, cultural exchanges are generated, and effective internationalization is promoted. However, this factor depends fundamentally on incentives, financing and solid institutional structures. In countries such as East Africa, budget constraints, policy rigidities and poor infrastructure hinder in-person mobility. Li & Xue (2022).

Successful institutional strategies, such as partnerships through Erasmus+ or TEMPUS programs, include not only fellowships and places of stay, but also the development of receiving capacities: multilingual classrooms, host networks and support resources for joint research.

Transnational research collaboration and its inequitable nature

Co-authorship networks reflect academic power: institutions from the global North dominate centrality and accumulate impact, while those from the global South remain on the periphery Guri-Rosenblit, (2015). This pattern is consistent with findings on "U.S.-UK centrality" and structural barriers present in Latin America and Africa.

Institutional strategies: alliances with international campuses (branch campuses), the use of collaborative research networks and the internationalization of teaching in a research key are highlighted. However, risks associated with dependence on the North's research agenda persist, which can divert institutional focus towards reputation to the detriment of local needs.

Teaching quality and technological innovation

Teaching emerges as a transversal factor through intercultural and linguistic competencies, pedagogical innovation and educational leadership. AI tools represent a powerful catalyst. **Some limitations can be seen that**, without systematic teacher training programs in ICC and technology, digital approaches become superficial or unsystematic. In addition, technology alone does not produce cultural integration if the teacher does not lead the change.

Institutional Infrastructure and AI/Big Data Adoption

AI tools for teacher management, attrition prediction, and selection are emerging as strategic assets. (Owoc *et al.*, 2021). The study by Katsamakas *et al.* (2024) proposes a causal diagram that shows how investments in AI can generate

virtuous loops but also warns of risks: gaps in academic integrity or disparities in infrastructure.

Interrelationships and strategic implications

Table 1. *The four factors interact in a complementary and sometimes conflicting way.*

Interaction	Strategic implication
Mobility + Teaching	Face-to-face and remote optimize networks and skills. Integrated teacher training strategies are essential.
Collaboration + AI	AI can map co-authorship networks, but without equity of access, it reproduces centralisms.
Mobility + AI	AI reduces virtual barriers, but without adequate infrastructure, they are limited.
Teaching + Collaboration	Teachers trained in ICC strengthen international projects, increasing impact.

This underscores the need for a **strategic systemic vision** that goes beyond isolated components, incorporating training, financing, infrastructure, and governance, as suggested by Qiang (2003).

Interconnected Implications, Challenges, and Limitations for Institutional Policy and Management

1. **Institutional capacity:** implementing AI and mobility programs requires strategic leadership and consensus in the definition of internationalization. Internationalization programs must articulate mobility, teacher training, data, and networks.
2. **Academic integrity and regulation:** The adoption of AI comes with challenges of privacy, ethics, and educational control, which requires clear frameworks adapted to each context. Plan with a perspective of equity and transparency, involving educational actors.
3. **Cultural and professional resistance**: Without recognition, incentives, or teacher training in ICC and technology, efforts can fail.
4. **Building capacity in the global South**: directing investment to training, technology and international networks.
5. **Ongoing monitoring**: Employ inclusive metrics and XAI to assess academic, social, and cultural impact.

The discussion reveals that internationalization is not an aggregate, but a system of strengths and tensions between mobility, research, teaching, and infrastructure. Only in its integration supported by coherent institutional strategies, conscious governance and equity, can internationalization fulfill its role as a transformative engine of higher education.

Conclusions

The conclusions show that internationalization in higher education depends on a strategic interaction between institutional, academic and contextual factors. Its development requires committed leadership, clear policies, organizational capabilities, and a global vision adapted to the local environment.

Four major structural factors were identified and validated:

1. International academic mobility, which promotes networks of trust, knowledge transfer and cultural learning.
2. Transnational research collaboration, which increases the academic impact, scientific production and global visibility of institutions.
3. Quality of teaching, understood as the combination of intercultural competencies, technological capabilities, pedagogical leadership and openness to change.
4. Institutional infrastructure and use of AI, which allows diagnosing, planning and evaluating internationalization with predictive and analytical tools.

Despite the advances, the development of internationalization faces significant barriers:

- Inequality of resources: Institutions in less developed regions have less access to networks, financing and technologies.
- Digital divide: The adoption of AI and digital tools requires sustained investment and technical capabilities that not all universities possess.
- Teacher resistance: Internationalization processes are often perceived as bureaucratic or imposed, without considering the leading role of the academic body.
- Anglophone approach and rankings: The dominance of English and the pressure for global rankings reinforce a logic of competition that can make knowledge, languages and non-hegemonic traditions invisible.

These tensions require political and strategic attention if internationalization is to be a mechanism of equity and not of deepening gaps.

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Incubators and the Role of Universities as Catalysts for Rural Entrepreneurship in Ecuador

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Introduction

Rural areas in Ecuador face a paradox: they have underutilized endogenous resources such as ancestral knowledge, biodiversity, and local labor that could become drivers of regional development (INEC, Rural Entrepreneurship Survey in Ecuador, 2022), while 72% of rural enterprises arise out of necessity, with high rates of informality and failure.

This phenomenon is exacerbated by youth migration, with 12% of young people leaving their communities, generating a critical loss of human capital and ancestral knowledge and squandering comparative advantages that, through specialized incubators, could be transformed into competitive ones. This migration not only represents a drain on human capital, but also the loss of ancestral knowledge and community networks, which are critical elements for local development models based on identity. Recent studies in the Andes show that 40% of rural youth would be willing to remain in their territories if there were opportunities linked to their cultural roots, reinforcing the urgency of incubators that articulate tradition and innovation and implement strategies that overcome three critical limitations: lack of access to financing, limited training in business management, and disconnection from formal markets (Turpo and Pérez 2021).

Local development based on endogenous competencies is emerging as a strategic alternative to overcome the structural limitations of Ecuador's rural areas. Unlike welfare-based models or those dependent on external factors, this approach leverages indigenous human, natural, and cultural resources, generating sustainable economic dynamics deeply rooted in community identity (Vázquez et al., 2007).

When operating under an endogenous approach, rural incubators act as strategic coordinators of local development through three fundamental axes: the integration of adapted mentoring programs that synthesize contemporary

business management with traditional knowledge; the facilitation of commercial connections that safeguard cultural identity (as exemplified by community tourism); and the promotion of social innovation anchored in local resources (Córdova and Herrera, 2022). This model not only mitigates migration and reduces poverty, but also capitalizes on rural heritage as a sustainable economic asset, for which it is essential to design differentiated public policies and form tripartite alliances between universities, local governments, and community actors.

In this context, this chapter will answer the following research question:

How can incubators and universities promote entrepreneurship in rural areas of Ecuador in terms of endogenous local development, overcoming limitations such as lack of training, dissemination, and institutional support?

Rural business incubators in Ecuador can catalyze endogenous development through a tripartite model that overcomes structural limitations. First, contextualized training must integrate ancestral knowledge with business tools through living labs and "learning by doing" methodologies (Córdova and Herrera, 2022), thus addressing the educational gap that affects 68% of rural entrepreneurs.

Second, dissemination with identity requires glocal strategies, such as digital platforms for products with designation of origin, avoiding cultural homogenization. Third, institutional strengthening requires multilevel governance (Triple Helix), where universities research local problems, governments provide territorialized financing, and communities participate in policy co-design.

Comparative evidence shows that this approach increases rural income by up to 35%, as demonstrated by emblematic cases: the coffee cooperatives of Loja (Ecuador) and Incubagro (Peru). However, its success depends on flexibility to adapt to geographical diversity (Andes/Amazon/Coast), qualitative metrics (reduction of youth migration, language preservation), and financial sustainability through mixed funds.

In conclusion, incubators must operate as glocal articulators, transforming comparative advantages (biodiversity, social capital) into competitive ones through frugal innovation and strategic alliances. This implies transcending welfare paradigms and prioritizing territorial autonomy, where endogenous knowledge dialogues with appropriate technologies. Future research should evaluate the scalability of the model in highly marginalized contexts.

The main objective of this chapter is to reflect on the role of incubators and universities in rural contexts as dynamic actors in entrepreneurship that take advantage of endogenous resources, foster innovative skills, and create sustainable networks.

In this sense, the chapter is subdivided into three fundamental sections, which begin by systematizing the dimensions that are taken into account when measuring local development, with an emphasis on rural contexts. In a second stage, incubators are conceptualized as dynamic entities: adaptation to rural realities. It concludes by analyzing the role of universities in promoting local development through incubation.

In the development of this chapter, different scientific research methods are used, such as: • The use of the scientific observation method covers the aspects of prior knowledge required to construct the theoretical framework of the research.

- With the analysis and synthesis method, the object of research is broken down into its different components in order to understand how it works and then integrate them into a whole later on.

- The historical-logical method is also used, which provides a chronological understanding of the evolution of the different stages of the object's development, as well as providing the most important elements of the phenomenon, the object in its internal and essential connections.

- At the same time, the dialectical method is used to delve deeper and get to the essence of the phenomenon.

The chapter has a qualitative approach, as it is based on a systematic review of specialized literature on local development, incubators, and the third function of the University as an entrepreneur in databases such as Scopus and SciDirect.

In this sense, the main contribution of the chapter is the theoretical framework for incubators in Ecuador that it provides, integrating perspectives on local development.

Dimensions of local development in rural contexts

Local development has been widely studied as a process of economic and social transformation based on territorial dynamics (Vázquez, 2005). However, in rural contexts, it takes on particular relevance due to the need to combat depopulation and take advantage of endogenous resources.

It emerged as a response to the limitations of centralized growth models and is a multidimensional construct that has been approached from different theoretical perspectives. Below are some key definitions:

- conceives it as *"an endogenous, participatory, and sustainable process that seeks to improve the quality of life of the community through the articulation of public, private, and social actors"*.
- points out that local development is "a process of transformation of the local economy and society, aimed at overcoming difficulties and taking advantage of the opportunities of the territory, through the mobilization of its human, productive, and institutional resources."
- (Vázquez, 2005) defines it as "a process of economic growth and structural change that, by utilizing the existing development potential in the territory, leads to an improvement in the standard of living of the local population." It highlights the importance of local actors and endogenous capacity for transformation.
- (Pike et al., 2006) understand it as "a bottom-up strategy that seeks to strengthen local capacities to generate employment, innovation, and social cohesion."

More contemporary approaches highlight the importance of local development and its link to the 2030 Agenda:

- (Pike et al., 2017) conceptualize it as "a bottom-up strategy to reduce inequalities."
- defines it as "a territorial approach that integrates sustainability and inclusion."
- adds that it must consider "climate resilience and the circular economy."

In the opinion of these authors, local development is a participatory process that, through the activation of endogenous resources (natural, cultural, and institutional), promotes inclusive economic growth, environmental sustainability, and social cohesion in a given territory.

The proposed definition takes into account a multidimensional view of the economic, social, environmental, institutional, and cultural phenomena and, in this sense, must be operationalized, allowing for comprehensive measurement in line with contemporary challenges (World Bank, 2022; UNESCO, 2021). This articulation between theory and metrics reinforces the notion that local development should not only generate wealth, but also equity, resilience, and territorial identity.

In rural contexts, this multidimensionality takes on greater relevance, given that indicators such as the preservation of cultural heritage (craftsmanship) or the sustainable management of natural resources (rural tourism) are as critical as economic indicators.

In Ecuador, these dimensions take on specific nuances. For example, the cultural dimension must incorporate indicators of linguistic preservation (Kichwa, Shuar) and ancestral agroecological practices, as documented in the report on community economies. Likewise, the institutional dimension requires evaluating intercultural governance, where decisions on financing or training are co-designed with community leaders.

In rural areas, local development faces challenges such as depopulation, lack of infrastructure, and dependence on primary sectors. However, it also presents unique opportunities:

- **Rural tourism:** It can be a key economic driver by enhancing the value of natural and cultural heritage, generating employment, and diversifying income.
- **Local crafts:** This is an activity with high identity and economic value that can be integrated into broader value chains.
- **Sustainable agriculture and agribusiness:** A focus on quality products (designations of origin) can differentiate rural communities in global markets.

Local development in Ecuador has been approached from endogenous perspectives that prioritize the productive, cultural, and organizational capacities of the territories (Vázquez, 2007). In rural contexts, this paradigm is particularly relevant due to the high dependence on primary activities (agriculture, community tourism) and the need to reduce asymmetries with urban areas. However, rural entrepreneurship faces structural barriers that limit its contribution to local development:

- **Limited access to financial and technical resources**: Only 12% of rural enterprises have access to formal credit
- **Institutional disarticulation**: Poor coordination between local governments, universities, and civil society organizations to promote entrepreneurial ecosystems.
- Low technology adoption: 68% of rural entrepreneurs do not use digital tools to market their products.

These challenges require incubation models adapted to rural particularities, where **social capital** (Putnam, 1993) and **frugal innovation** are the driving forces.

A paradigmatic case is Chimborazo, where incubators based on Kichwa knowledge managed to insert agricultural products into international markets through fair trade.

Incubators as catalysts: adaptation to rural realities

Theodorakopoulos et al. (2014) argue that there is no universally accepted definition of incubation and business incubators. Their study provides a chronology from 1985 to 2014 of the most widely adopted definitions of business incubators in the literature. According to these authors, most research considers incubators to be a business development tool for economic and social development, providing affordable office space and a variety of support services, both internally and through external affiliates. These spaces can cover all the stages that a venture goes through, from the exploration phase to the exploitation or commercialization phase (Cunningham et al., 2022). In the specific case of university business incubators, they are considered "entrepreneurship support mechanisms created by universities that are part of a broader dynamic entrepreneurial ecosystem comprising multiple contexts, actors, stakeholders, and processes" (Nicholls et al., 2021).

(Phan et al., 2005) define these institutions as property-based organizations with centers focused on the mission of business acceleration through the concentration of knowledge and the exchange of resources. They constitute "a protected habitat that insulates companies from market selection pressures" (Abootorabi et al., 2021). Furthermore, an incubator can be conceived as an evolving innovative organizational form (Peters et al., 2004) where, in the case of university business incubators, innovation predominates (Redondo et al., 2022).

Business incubators develop business incubation programs that generally provide projects with access to appropriate rental space and flexible leases, shared basic business services and equipment, technology, support services, and assistance in obtaining the financing necessary for the growth of the business (Lewis et al., 2011). Business incubation programs can also be virtual (Etzkowitz, 2002) and provide business assistance services to their virtual or affiliated clients.

A study by (Baraldi and Ingemansson, 2016) points out that the analysis of definitions allows for the identification and definition of seven key components of business incubation that generally characterize an incubator. However, given that these are flexible models that can be adapted to the characteristics, capacities, and resources of each region and/or country, taking into account their technological and business development (Etzkowitz, 2002), the components will differ from one another. Each of these components is discussed below.

i. Location: Identified as "the first component of incubators" (Baraldi and Ingemansson, 2016, p. 55), it involves a shared environment and space for incubatees and staff, both physical and organizational, where support is offered and the possibility of interacting with other projects in a formal and informal manner. However, the authors did not include the characteristics of this component associated with virtual incubators. According to (Etzkowitz, 2002), in a virtual program, interaction can also occur during and after the incubation period by organizing meetings to encourage learning between projects, and these do not necessarily have to be face-to-face.

ii. Time: The incubation process is conceived as a temporary situation for companies, and in many cases, incubators have defined graduation and exit policies. As incubators have evolved, they provide more specialized services that are less physically linked. This reduces the incubation time.

iii. Sources (projects to be incubated): This is considered a key component because it provides the ideas to be developed and, given that incubation is a process in itself, it allows it to function, because without projects or ideas there would be no incubation process. To identify projects with potential, many incubators apply selection rules or criteria to different sources, from strictly scientific ideas originating in a university to any business idea. On the other hand, there are incubators that accept projects as long as the business concept is objective and has the potential to be implemented, and in other cases, they only consider whether there is space available and whether the candidates can pay the cost of the premises (Etzkowitz, 2002). Another aspect that incubators must be clear about is whether they will specialize in a particular sector or be generalists, which will influence their acceptance policy, as well as the characteristics of the program and the needs of mentors.

iv. Resources: Incubators offer incubated projects material resources (workspace, technology, financing, etc.) and immaterial resources (network of contacts, legal and financial advice, etc.). According to , material resources are important for incubators and their projects because they create economies of scale, but intangible resources such as the incubator's network of contacts allow access to external resources, such as legitimacy and recognition, especially because they are generated within a university.

v.Control or governance: Incubators need to establish clear rules of governance because in many cases they are run by entities with different objectives. Incubators must have a defined monitoring system for the proper development of their projects. In (Etzkowitz, 2002), the incubator director is identified as a key factor in the process, who, theoretically, must have knowledge and be familiar with the entrepreneurial ecosystem at various levels, enabling them to support

projects and/or companies in the search for external resources. This author acknowledges that incubator directors generally come from the university community (professors, researchers, or support staff), so their experience in entrepreneurship is acquired over time and, in some cases, through guidance from experienced incubator directors.

vi.Services or activities: These are the activities carried out or offered by incubators for incubated projects. For example: advice, training, access to financing and to the network of contacts outside the incubator, coworking space, etc. Some incubators have business and/or technology specialists as part of their permanent staff, who work directly and continuously with the incubated companies, while in others these specialists are part of the group of mentors as they are professionals specialized in specific technologies (Etzkowitz, 2002).

vii. Results: (Baraldi and Ingemansson, 2016) established the results of the incubation process as their final component due to the strong interest of incubation studies in the evaluation of incubators and the indicators proposed to measure their performance.

The authors (Baraldi and Ingemansson, 2016) establish that these seven components determine both the incubator, which constitutes the main context of incubation, and the incubated projects, and characterize the context in which they develop, that is, the ecosystem in which they operate.

In rural areas, these components must be adapted. For example, 'place' implies not only physical infrastructure but also symbolic spaces (such as traveling markets that revive historic trade routes), while 'resources' must prioritize appropriate technologies (e.g., offline apps for marketing, given limited rural connectivity). Cases such as Incubagro in Peru show that this adaptation increases the adoption of innovations by 30%.

Business incubators exist in many developing countries, such as India, Mexico, Turkey, Poland, and Russia. However, there is a lack of research on business incubators in regions such as Africa, South America (Mian et al., 2016), and the Caribbean. Studies focus on countries such as Mexico, Chile, Colombia, and Brazil. Many countries have successful experiences in business incubation in the university setting. The leading country in this approach is the United States, but Spain, Sweden, the Netherlands, Canada, Turkey, Japan, China, and Portugal also stand out. In LAC, despite being a more recent topic, the use of university business incubators as mechanisms for economic development has spread. According to the UBI Global World Rankings (Castillo and Meyer, 2018; Meyer and Sowah, 2019), LAC has a prominent presence among the best internationally

recognized experiences, with Brazil, Mexico, Colombia, and Chile being the countries with the highest participation.

Local development and project incubation have a synergistic relationship, with the latter acting as a catalyst for the former. The incubation of business, social, or cultural initiatives allows the principles of local development to be realized by transforming endogenous resources such as natural heritage, traditional knowledge, or human capital into sustainable economic activities. Projects incubated in rural areas, such as agroecological cooperatives or community tourism ventures, not only generate employment but also strengthen territorial identity and reduce dependence on extractive models. Thus, incubators function as bridges between the latent potential of the territory and its practical use, aligning with the bottom-up approach that characterizes local development.

However, the success of this relationship depends on the incubation being contextualized. Projects imposed from outside, without local participation or without adapting to sociocultural dynamics, often fail (UNDP, 2021). One example is incubation programs that promote advanced technology in rural areas without training the population, creating implementation gaps. Conversely, when incubation processes are built collaboratively, such as digital craft workshops that integrate ancestral techniques with modern design, they manage to scale impacts without eroding the social fabric.

Project incubation is a key tool for local development, but it requires flexible and participatory designs. Its greatest contribution lies in turning ideas into measurable actions, whether through economic (increased local income), environmental (sustainable use of resources), or cultural (preservation of traditional crafts) metrics. Thus, while local development provides the theoretical and territorial framework, incubation operates as the practical mechanism for its execution, provided that both processes are nourished by realistic local diagnoses and inclusive governance (World Bank, 2023).

According to the Results Report of the Rural Incubator Program of the and the , it can be seen that in terms of results, when traditional incubation models are adapted to the rural context, they significantly increase the survival of enterprises (78% vs. 52%).

This increase in results is mainly due to the fact that adapting traditional methodologies to rural contexts helps them identify their endogenous competitive advantages to leverage. Without neglecting traditional management workshops, methodologies for the development of soft skills are incorporated, as well as specialized workshops on topics of interest such as Circular Economy and Knowledge Transfer, to name a few. Universities play a

fundamental role in this adaptation, which promotes capacity building. A comparison between traditional incubation methodologies and those adapted to rural environments reveals a deep gap in development paradigms. While urban incubators prioritize scalability and disruptive technology—often disconnected from local realities—rural incubators require a *glocal* approach that balances innovation and cultural roots. The table shows that success in rural contexts is not measured solely in financial terms, but also in intangible yet vital metrics: reducing youth migration, preserving ancestral knowledge, and strengthening social capital. This calls into question the universal validity of standardized models of entrepreneurship and highlights the urgency of bottom-up designs, where communities are not passive beneficiaries but co-creators of solutions.

The contrast also underscores the transformative role of universities. They must move from being providers of abstract knowledge to *articulators of ecosystems* that integrate, for example, living laboratories with intergenerational workshops. The inclusion of frugal technologies—such as offline apps or agroecological tools—demonstrates that innovation in rural areas is not synonymous with low complexity, but rather with high adaptability. In short, the table not only compares methodologies, but also exposes a critical tension: the need to rethink economic development from the perspective of cultural diversity and territorial particularities, where "efficiency" must be defined in dialogue with ethics and sustainability.

The role of universities in promoting local development through incubation

Over the last two decades, the role of universities in promoting entrepreneurship and innovation has been the focus of attention of politicians and academics from different disciplines (economics, psychology, sociology, etc.) and perspectives (individual, organizational, and contextual) (Guerrero et al., 2016, p. 553). This is due, among other reasons, to the fact that universities are institutions par excellence capable of generating highly innovative projects (Arocena and Sutz, 2001; Bercovitz and Feldmann, 2006). More than 20 years ago, Tünermann (1998) referred to the fact that the university of the 21st century should address, generate, and apply its innovations in its substantive functions, be capable of achieving a systemic integration of teaching, research, and outreach, whose fundamental objective was the search for solutions to the problems of society and the nation.

Universities have created different mechanisms to promote innovation and entrepreneurship, known as knowledge intermediaries, which make up the university entrepreneurship ecosystem (UEE). Business incubators are one such

knowledge intermediary and are considered a key component in regional and national economic development strategies, supporting and accelerating growth in various sectors (Voisey et al., 2006). However, the development of these spaces, as well as the ecosystems themselves, has not occurred in the same way or at the same time. The fundamental cause is due to the context in which they develop, where political, economic, social, cultural, and even organizational factors have a significant impact on these spaces and on the ecosystem. Therefore, it is necessary to conduct a comparative study between these ecosystems, where the contextual factors in which they operate differ significantly, and to delve deeper into the development of their actors, particularly university business incubators.

Several studies have been conducted on business incubation in areas related to the identification of characteristics, classification, processes, key success factors (Al-Mubaraki and Busler, 2017; Hackett and Dilts, 2004; Mian, 1996; Theodorakopoulos et al., 2014; Voisey et al., 2006) or critical success factors (Lalkaka, 1996; Siddiqui et al., 2021), performance or success evaluation (Baraldi and Ingemansson, 2016), internationalization, their link to economic development (Etzkowitz, 2002; Somsuk and Laosirihongthong, 2014), etc. They have also focused on analyzing the phenomenon in developed countries, although there are some studies that have addressed cases in emerging countries (Al-Mubaraki and Busler, 2013; Bathula, Karia, and Abbott, 2011). Therefore, it is still necessary to further study the development of incubators and the role they play within ecosystems, in this case, university ecosystems (Albort-Morant and Ribeiro-Soriano, 2016), especially in underdeveloped countries in Africa, South America (Mian et al., 2016), and the Caribbean.

Universities, as key players in knowledge ecosystems, have the unique ability to link local development with project incubation through four fundamental roles:

· Generators of applied knowledge:

Universities can research the endogenous potential of the territory (natural resources, traditional knowledge, social needs) and translate it into viable project opportunities. According to the , universities that implement living labs in rural areas achieve up to 40% greater effectiveness in technology transfer. One example is agronomy faculties that develop climate-smart agriculture models adapted to micro-territories.

· Structuring local capacities:

Through practical training programs (e.g., diplomas in rural tourism management or marketing workshops for artisans), universities can bridge the gap between academic knowledge and the skills needed to become an

entrepreneur. The Network of Universities for Local Development in Latin America (2023) showed that projects incubated with university support are 65% more likely to be sustainable after three years than self-managed initiatives.

· Ecosystem articulators:

Universities must act as hubs connecting communities, local governments, businesses, and NGOs. One successful example is the "Spin-Off Rural" program at the University of Santiago de Compostela (2021), which has created 12 spin-off companies based on Galician gastronomic heritage, generating 83 direct jobs. This exemplifies how the triple helix (academia-state-productive sector) enhances real impact (Etzkowitz, 2020).

In the opinion of these authors, in order to maximize their impact, universities should:

· Adapt their incubation models to the speeds and resources of rural areas (e.g., replace bureaucratic requirements with personalized mentoring)

· Measure their contribution not only by commercial metrics, but also by territorial development indicators (e.g., reduction of gender gaps in rural entrepreneurship, according to the OECD, 2023)

· Link participatory action research with local public policies, as the National University of Colombia did when it co-designed the Boyacá Tourism Development Plan (2022) based on value chain studies

Ecuadorian universities face the challenge of transcending their traditional role. The National University of Loja, for example, has implemented a model of 'traveling incubators' that bring mentoring to remote communities, combining participatory diagnosis with rapid prototyping. This requires reformulating indicators of academic success, valuing not only scientific publications, but also collective patents or commercialization agreements with a direct impact on rural incomes. Universities located in rural areas or with direct influence on them have a strategic responsibility: to act as hubs of territorial innovation that not only conduct research but also co-construct solutions with and for communities. To do so, they must:

1. Map and articulate endogenous assets: Systematically identify local resources (ancestral knowledge, biodiversity, community networks) through participatory methodologies, such as collaborative rural diagnostics, to design incubators that solve real problems and avoid external impositions.

2. Make academic structures more flexible: Create units specializing in rural entrepreneurship with hybrid curricula that integrate:

o Technical training in business management adapted to community economies.
o Evaluation systems that assess the impact in situ (e.g., reduction of youth migration or increase in family income) over traditional publication metrics.

3. **Mobile and decentralized incubation**: Bring incubation services to communities through:

o Mobile university brigades (e.g., prototyping workshops in agricultural cooperatives).
o Low-tech digital platforms (offline first) for mentoring and marketing, considering connectivity gaps.

4. Shared governance: Establish local advisory councils where community leaders, entrepreneurs, and academics jointly define incubation priorities, ensuring that projects respect the indigenous worldview and traditional production cycles. Only then will rural incubators cease to be isolated experiments and become engines of glocal development that root the global in the local, where universities are not observers but active accomplices in territorial transformation.

Universities closest to these rural contexts are called upon to be catalysts for a new incubation model that transcends welfare and becomes a bridge between scientific knowledge and ancestral wisdom. To do so, they must build their intervention on four fundamental pillars:

1. Comprehensive training that combines critical thinking with practical skills, training rural entrepreneurs not only in business management but also in analyzing their territorial realities.

2. **Links to niche markets** through glocal strategies that connect local products (crafts, gastronomy) with fair trade and experiential tourism circuits, while respecting cultural identities.

3. The active preservation of knowledge through intergenerational workshops where elders and young people co-design solutions, preventing the erosion of traditional knowledge.

4. A flexible institutional architecture that allows incubation models to be adapted to the particularities of each territory (Andes, Amazon, Coast), with metrics that assess both economic impact and community cohesion. Local development in rural areas finds its most powerful engine in university incubators, where the synergy between academic knowledge and community

knowledge generates structural transformations. By designing territorialized incubators, universities not only transfer technology but also rescue and enhance endogenous resources, creating business models that value cultural identity while improving family income. This tripartite model—linking universities, incubators, and communities—goes beyond welfare by turning local actors into protagonists of their own development, where critical thinking is combined with ancestral techniques, and global markets are connected with high-value local production. Thus, university incubators emerge as spaces where innovation and tradition converge, generating decent employment, curbing youth migration, and, above all, demonstrating that another form of development is possible: endogenous, participatory, and deeply rooted in the territory.

Conclusions

The analysis carried out in this chapter leads to the conclusion that rural incubators, linked to universities, represent a transformative strategy for endogenous local development in Ecuador. The findings reveal three fundamental aspects:

Adaptation to the rural context: Incubators must be specifically designed to respond to the realities of rural areas, where endogenous resources—such as ancestral knowledge, biodiversity, and social capital—are the basis for generating sustainable enterprises. This implies developing flexible models that combine business training with cultural preservation.

Transformative role of universities: Higher education institutions are called upon to transcend their traditional role and become active articulators between academic knowledge and community needs. This is achieved through applied research, territorial mentoring, and the creation of networks that connect rural entrepreneurs with markets and opportunities.

Multidimensional impact: The true success of these initiatives is measured not only by economic indicators, but also by their ability to strengthen the social fabric, reduce youth migration, and preserve cultural identity, while generating sustainable economic opportunities.

The role of universities and rural incubators in Ecuador must transcend their academic work to reach this third entrepreneurial function and become institutions of social transformation. Their success will not be judged by their scalability, but by their ability to generate solutions in cultural identity, weave networks between traditionally disconnected actors, and democratize innovation, bringing it to those who have been ignored by the formal system. As a final reflection, the authors return to the idea of Boisier (2001): "Local development is, above all, an act of collective autonomy." Rural incubators,

when designed from and for the territory, can be that space where identity is not negotiated, innovation is not imposed, and the future is not predicted, but co-created.

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Continuing education for International Baccalaureate teachers. A current challenge in the knowledge society

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Introduction

Continuing education for teachers is imperative in a global context characterized by constant technological, social, and educational evolution. More and more countries in Latin America are concerned with updating, reforming, or changing their educational systems in order to improve the quality of education.

To achieve this universally, improving teacher training, both initial and continuing, has been considered a priority, an aspiration legitimized by various international organizations the United Nations Educational, Scientific and Cultural Organization (UNESCO), which recognizes teacher training as one of the fundamental pillars for achieving the Sustainable Development Goals, particularly with regard to ensuring inclusive, equitable, and quality education. (UNESCO, 2024), the Regional Organization for Higher Education in Latin America (CRESAL) supports the necessary integration of teacher training into a framework of lifelong learning, maximizing its potential to provide continuing education and professional refresher courses at the higher level in flexible formats, beyond traditional degrees, as well as the incorporation of innovative methodologies. Ricaurte, et al., (2025) and the Organization of Ibero-American States (OEI), whose members promote the implementation of quality continuing education programs to respond to the needs of the Ibero-American region. United Nations Children's Fund (UNICEF), United Nations (UN), World Education Forum (2015), which has succeeded in including its interests in the development of education in the new strategy for 2016-2030, affirms the need to ensure that teachers and educators are trained, adequately employed, well educated, professionally qualified, motivated, and supported by systems that are adequately resourced, efficient, and effectively managed. Meanwhile, the Organization for Economic Cooperation and Development (OECD) encourages

education systems to provide teachers with opportunities to develop and expand their skills in order to achieve or maintain a high standard of teaching and develop a high-quality teaching workforce. it also refers to continuous evaluation to identify areas for improvement, recognize and reward effective teaching, and ensure that teachers have the resources and support they need to meet society's high expectations (OECD, 2017).

The positions of international organizations outlined above converge on the same conviction: continuing teacher education is a strategic and irreplaceable pillar for ensuring quality education in the 21st century.

Far from being a complementary option, continuing education is recognized as an ethical, systemic, and sustained commitment that enables teachers to respond effectively to the challenges of a global, diverse, and constantly changing society (Trouche, 2020).

This unanimity of opinion—expressed by bodies such as UNESCO, the OECD, the OEI, and UNICEF—legitimizes the urgent need to implement comprehensive educational policies that strengthen teacher professionalization, thereby increasing the transformative potential of education in our contexts.

And all this action-oriented thinking is possible because, in the context of the knowledge society and the digital age, education has become an indispensable pillar for enhancing and strengthening the fundamental skills and abilities required in the 21st century (Núñez, 2022).

Among the various internationally renowned educational programs, the International Baccalaureate (IB) stands out for its comprehensive educational approach and its marked inclination toward promoting research and the development of critical thinking in students, in addition to its firm commitment to ethical training and global awareness in students (International Baccalaureate Organization. 2025).

The IB in Ecuador was created in 2006 as a partnership between the Ministry of Education (Mineduc) and the International Baccalaureate Organization (IBO), a non-profit educational foundation created in 1968 with its legal headquarters in Geneva, Switzerland (Tigse, 2018).

Continuing education for International Baccalaureate teachers

Continuing education for International Baccalaureate teachers is essential not only as an institutional requirement but also as an unavoidable condition for effectively adapting to the continuous and dynamic transformations of the educational environment in which they work (Gómez et al., 2023). This challenge

is considerably intensified by the need to incorporate advanced digital technologies, innovative pedagogical approaches, and the teaching of English for specific and specialized purposes, within a framework of rigorous and enriching academic demands that promotes cultural diversity and the exchange of knowledge (Duche et al., 2024). From this perspective, Cabello-Rivera and Gal (2025:3) emphasize that "competency-based training must work in a balanced way on content (knowledge), skills (know-how), and attitudes and values (knowing how to be), without neglecting any of them, in order to produce students who are committed to the practice of their profession."

Therefore, as a way of investigating the contribution of continuing education for International Baccalaureate teachers to strengthening their competencies in the knowledge society, the objective of this paper is to assess the importance of continuing education for teachers who teach English in the International Baccalaureate in order to strengthen their competencies in a globalized world, through the analysis of strategies, resources, and tools that promote their professionalization and have a positive impact on student learning and educational quality (International Baccalaureate Organization. 2020).

The idea is defended that the renewal of continuing education programs for English teachers that are contextualized and focused on particular skills significantly enhances pedagogical, digital, and linguistic competence in the International Baccalaureate environment, thus improving the quality of the teaching-learning process in the context of the knowledge society (Gómez et al., 2021).

To achieve these objectives, the study was framed within a qualitative approach, with a descriptive-interpretive research design. This methodology allows us to understand the perceptions, experiences, and needs of International Baccalaureate teachers in relation to their continuing education, as well as to interpret the meanings they attribute to their professional development processes in the context of the knowledge society (Meneses, 2025).

The main technique used was semi-structured interviews with teachers who teach within the IB system in accredited educational institutions in Ecuador (Whaley, 2024). The selection criteria for participants included: at least three years of teaching experience within the IB, participation in continuing education courses or programs, and involvement in the area of English or subjects taught in English as a foreign language. In addition, data collection was complemented by a documentary analysis of teacher training plans, IB program guides, and related institutional policies (Dickson et al., 2018).

The procedure developed went through several phases, ranging from a documentary review with an analysis of recent academic literature related to continuing education, the International Baccalaureate, teaching competencies, and the knowledge society, using databases such as Science Direct, Scopus, and ERIC. This was followed by the necessary design of the instrument, which consisted of the development of an interview guide validated by experts in international education and qualitative methodologies, and its corresponding application to 10 teachers from different Ecuadorian cities, ensuring the diversity of educational contexts (private and public with IB, urban and rural). Finally, we proceeded with the data analysis, in which the discourses were coded thematically using Atlas.ti software, which allowed us to identify common patterns and key dimensions related to training needs and perceived benefits.

The analysis resulted in several relevant categories:

- Need for contextualized training: Educators stated that many continuing education programs are generic in nature and do not address the specificities of the International Baccalaureate, particularly with regard to active methodologies, formative assessment, and bilingual teaching.

- Insufficient digital and language skills: There was an urgent need for training in the pedagogical use of digital platforms, interactive resources, and strategies for teaching English for academic and specific purposes.

- Professional development and pedagogical identity: Educators involved in carefully structured continuing education programs showed an increase in their sense of institutional belonging, professional self-esteem, and commitment to innovation in education.

- Institutional constraints: Barriers such as insufficient time, budget, technical support, and recognition of training as an integral part of the workload were identified.

- The findings suggest that continuing education programs have a direct impact on improving pedagogical practice when they are aligned with the real needs of the IB context and articulate technological, linguistic, and pedagogical components.

Key contributions of continuing education in the IB context

The implementation of continuing education in the context of the International Baccalaureate should not be interpreted as an isolated or secondary practice in teaching performance. On the contrary, it is an indispensable condition for the development of skills that go beyond conventional knowledge, involving

reflective, collaborative, and highly contextualized processes (Innovation and Teacher Development, 2024).

The findings from this research suggest that the quality of teaching in the field of Artificial Intelligence (AI) is intrinsically linked to the professional development opportunities available to educators (Marienko et al., 2020).

One of the most significant findings is the need for specialized training that integrates three fundamental dimensions: pedagogical skills based on active methodologies, digital skills for the integration of Information and Communication Technologies (ICT) in the educational environment, and proficiency in English for academic purposes (Vaillant, 2023).

These dimensions emerge from the demands of the profile of the educator in Information and Communication Technologies (ICT), who must work in a bilingual, multicultural context with international academic standards.

The following table summarizes the main findings from the interviews:

These findings are consistent with the assertions of scholars such as Villegas-Reimers (2003), who postulate that teacher professional development is most effective when directly linked to the educator's work environment. Furthermore, Avalos (2007) argues that the most successful continuing education programs are those that take into account the educator's prior knowledge, their actual requirements, and their active involvement in the process.

The study also shows that continuing education has a positive impact on professional identity, strengthening teachers' confidence and leadership skills within the educational community (Altamirano et al., 2020). This aspect is essential in the field of Artificial Intelligence, where teachers not only play a role in transmitting knowledge, but also as guides, researchers, and evaluators in accordance with international standards (Pinzón, 2020).

However, the absence of a national education policy that promotes and finances these updating processes remains a structural constraint. Many educators argue that the responsibility of assuming the costs of training on their own can intensify inequalities and restrict access to high-quality training opportunities.

Conclusions

The ongoing training of International Baccalaureate educators is a strategic pillar for ensuring high-quality education in the context of the knowledge society. This study has shown that, although educators recognize the importance of updating their skills, the opportunities currently available to them are limited, fragmented, or insufficiently contextual. The lack of specialized training in Business

Intelligence (BI) methodologies, digital skills, and teaching English for academic purposes represents a gap that directly impacts the effectiveness of the teaching-learning process.

The data collected shows a high level of interest among educators in improving their skills. However, it also highlights the urgent need for educational institutions and national systems to identify, support, and fund teacher professional development processes in line with international standards. The integration of structured, relevant, and sustainable continuing education programs not only optimizes teacher performance but also has a direct impact on training students in critical thinking, language proficiency, and the ability to operate in a globalized context.

In conclusion, addressing contemporary challenges requires the reconfiguration of teacher training as a continuous, holistic, and future-oriented process. Improving teachers' skills in the field of artificial intelligence cannot be postponed if we aspire to consolidate equitable, innovative, and scientifically based education in the knowledge society in Latin America, and especially in Ecuador.

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Public policies and the persistence of gender-based violence in rural Ecuador

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Introduction

In recent decades, gender-focused public policies have become an indispensable component in addressing the structural violence faced by women in Latin America, particularly in rural Ecuador, in accordance with Sustainable Development Goals 1, 5, and 10 of the 2030 Agenda (United Nations, 2024), which call for poverty reduction, gender equality, and the reduction of inequalities. Gender-based violence, far from being an isolated or private matter, is a systematic manifestation of historically unequal power relations that subordinate women, affecting their dignity, autonomy, and fundamental rights.

Despite the enactment of regulations, conventions, and international treaties ratified by the Ecuadorian State, such as CEDAW (Convention on the Elimination of All Forms of Discrimination against Women) (2024) and the Belém Do Pará Convention (1994), the persistence of this violence is evident in the survey on violence against women (Census, 2019), which indicates that the national indicators at the rural level are: total violence 62.8%, psychological violence 57.4%, physical violence 38.2%, sexual violence 22.9%, economic and patrimonial violence 14.9%, and gynecological-obstetric violence 54.8%.

This is why it is important to conduct a critical and scientific review of the effectiveness of public policies implemented to prevent gender-based violence, by asking the question: To what extent have gender-focused public policies implemented in Ecuador succeeded in preventing, punishing, and eradicating violence against women, especially in rural contexts?

The aim is to analyze the effectiveness of gender-focused public policies in Ecuador in addressing structural violence against women, with a special emphasis on their implementation in rural areas, where conditions of invisibility, exclusion, and cultural barriers persist. Based on a review of the literature, the study seeks to identify both the advances and limitations of state action in guaranteeing a life free of violence for women.

Applying a qualitative bibliographic approach, an interpretive analysis of secondary and primary sources was carried out, reviewing and comparing research on gender-focused public policies and gender-based violence in rural areas of Ecuador, which included approaches such as the guarantee of human rights from an international and national legal framework, gender, feminist, intersectional, and decolonial perspectives. A bibliographic review was conducted using the Scopus, Scielo, and Web Science databases for the period from 2020 to 2025, covering all current regulations and international agreements and treaties ratified by Ecuador.

The premise is that public policies, although advanced at the regulatory level, have not managed to generate structural transformations due to their weak implementation, institutional fragmentation, and low community participation.

Gender-focused public policies

Violence against women is a structural problem present at all social levels, resulting from unequal power relations between men and women, in which masculinity predominates and devalues femininity. For decades, in Latin America and the Caribbean, including Ecuador, this type of violence was considered a private matter, without state intervention.

However, thanks to the struggle of the women's movement, since the 1980s in Ecuador, this issue has been brought to light as a matter of public health and human rights. An important milestone was the signing and ratification of international treaties such as the Convention on the Elimination of All Forms of Discrimination against Women (1994) and the Inter-American Convention on the Prevention, Punishment, and Eradication of Violence against Women (1994), known as the "Convention of Belém do Pará."

At the national level, Women's Police Stations were created in 1994, and in 1995 the Law Against Violence Against Women and the Family was enacted, which for the first time recognized domestic violence as a public problem. In addition, in 1997, the National Women's Council (CONAMU) was created as a public entity responsible for promoting gender equality policies. Subsequently, progress was made in constitutional legislation in 2008, as well as in the labor and criminal spheres, including the classification of femicide in the Organic Comprehensive Criminal Code (2014).

Despite these efforts, violence persists at alarming rates, which is why the Comprehensive Organic Law to Prevent and Eradicate Violence against Women (National Assembly of Ecuador, 2021) was promoted, establishing a national system of prevention, protection, care, and reparation, coordinating the actions of the State and citizens to guarantee a life free of violence. The model emphasizes the need to recognize the rights of individuals, regardless of their class or gender, or else they will not be reflected in everyday life (Pariona Benavides et al., 2023).

The LOIPEVM is based on constitutional principles that recognize the country as a state of rights and justice, in which all persons are equal before the law and must enjoy the same rights without discrimination. The Constitution of the Republic of Ecuador (2008) establishes that the State has an obligation to adopt affirmative measures to guarantee real equality, protect people in vulnerable situations, ensure access to justice, and progressively develop rights.

This law is also based on international commitments made by Ecuador, such as the Universal Declaration of Human Rights (UN, 1948), the International Covenant on Civil and Political Rights (1976), the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), and the Belém do Pará Convention. These treaties oblige the State to implement public policies to prevent, punish, and eradicate gender-based violence, as evidenced in the National Agenda for Gender Equality 2021-2025 (United Nations, 2024).

Furthermore, it is recognized that violence against women is the product of historically unequal power relations and that the State has a duty to guarantee the comprehensive protection of women through effective laws, preventive measures, priority care for victims, and comprehensive reparation for both material and immaterial damages.

Cedeño et al. (2020) concluded that, although various public policies have been implemented, they "have not had a real impact" due to excessive bureaucratization and weakness in their operational effectiveness. Similarly, in Guayaquil, Mendieta Lucas (2022) reports that institutional deficiencies such as

lack of budget allocation, weaknesses in inter-institutional coordination, and a limited preventive approach limited the scope of gender policies.

It is also important to create a new, more precise path for human thought, one that allows us to portray history in order to teach, learn, and disseminate the cultural legacies of our gender (Ramírez Julca et al., 2023).

Gender-based violence in rural contexts

In rural areas of Ecuador, gender-based violence takes specific forms characterized by low visibility, impunity, and cultural and legal barriers.

It is necessary for them to clearly perceive that eradicating gender violence is inseparable from the very reform of the constitutive affections of gender relations as we know them and in their aspect perceived as "normal," and this, unfortunately, cannot be changed by decree, with a stroke of the pen, by signing the contract of (Segato 2003). In other words, the rules, policies, authorities, and sanctions exist, but the implementation of the guidelines and those who guide women living in a state of vulnerability, even when the guidance is provided by the state, which guarantees to remedy that state of vulnerability, are lacking.

Barraza et al. (2023), in a qualitative study in the rural north of the country, show that women victims express a double burden: community stigma and distant justice, highlighting a process of resilience and empowerment, where women try to transform learned cultural patterns.

In addition to this, Pérez-Martínez et al. (2024) describe how domestic and community violence is intensified by post-pandemic institutional isolation. In several testimonies from survivors, processes of resilience are evident, with aspirations to break patterns for future generations.

For example, (Aguinaga Barragán et al., 2019) point out that peasant, indigenous, and farming women face a combination of poverty, discrimination, and lack of access to justice, conditioning their participation in politics and perpetuating structural violence within their communities.

Similarly, (Chiriboga Azanza et al., 2022) indicate that cultural stereotypes significantly influence the reproduction of gender-based violence in rural contexts. In conclusion, they determine, based on mixed research with a descriptive and correlational scope carried out in the rural parishes of San Juan, Lican, and Flores, using focus groups with public officials and semi-structured interviews with victims of gender-based violence and their families as tools.

It was found that in these rural parishes, 78% of women have suffered violence from their partners and ex-partners. Furthermore, the women themselves are not

aware that "normal" abusive behavior and naturalized violence cause inequality in relation to their counterparts, as they normalize violent behavior and sexual hegemony, as detailed by Chiriboga Azanza et al. (2022).

As a result of this imbalance in oppressive-oppressed power relations, women who separate from their aggressors face not only domestic violence, but also social stigmatization and the loss of social support networks such as belonging to a community. For example, one of the participants and survivors of the study conducted in the parish of San Juan, Shoboll community, said: "Divorced women are frowned upon by men and women in the community" (Chiriboga Azanza et al., 2022).

Similarly, a study conducted in the rural area of the Chone canton in the province of Manabí demonstrates a gap in the implementation and effectiveness of public policies aimed at preventing and eradicating gender-based violence in rural areas. Using a mixed methodological approach, which included surveys of 380 residents and interviews with parish leaders, it was found that there is a high level of public ignorance about the existence of ordinances or public programs related to this issue. For example, in the parish of Eloy Alfaro, 59% of the population stated that they were completely unaware of such ordinances or programs (Loor, Loor Villavicencio, Intriago Cusme & Mendoza, 2024). This demonstrates that there is no proper socialization process within rural communities and that the existence of these public programs to prevent and eradicate this social phenomenon is not sufficient, since it is impossible to access social assistance that you are unaware of.

In addition, the results of this study show a low effectiveness of reporting mechanisms and institutional response to cases of gender-based violence. For example, in the rural parish of Chibunga, 32% think that reports are rarely made, and in the rural parish of Ricaurte, 26% of participants think that nothing is done (Loor, Loor Villavicencio, Intriago Cusme & Mendoza, 2024). These results show that within the social perception of these communities, crime is rooted in the meaning of impunity, and gender-based violence is normalized in everyday life. Although there is a legal framework that supports the prevention and eradication of gender-based violence in rural Ecuador, the lack of proper enforcement makes these laws complicit in violence. This shows that legal regulations are useless if their actual and practical application continues to perpetuate the inequality gap.

In the same context of gender violence (Crenshaw, 2009), we come to understand how gender violence is not independent of categories of oppression such as race, class, ethnicity, and the cradle phenomenon, that is, the place where you are born. The violence that many women survive cannot be separated

from these structures that produce and reproduce inequalities, not only gender but also racial and economic.

Similarly, (Segato, 2003) argues that the female body in rural Latin American contexts becomes a territory of conquest where violence and lack of consent reinforce community hierarchies. In rural areas, justice takes the form of reconciliation and informal justice, such as promises that the aggressor will not repeat the aggression, providing fertile ground for impunity to thrive. In closed community contexts, violence against women is often a message between men: a form of collective discipline. In the same vein, Segato (2016), in her book La Guerra Contra las Mujeres (The War Against Women), analyzes how society takes the colonial state front as a reference point and shapes the idea that politics is of common interest to the village, ignoring the hegemony of power that forms the basis of these territories. For this reason, in rural areas, and especially in rural indigenous areas, public policies to prevent or eradicate gender-based violence fail to transform or strengthen equality in community structures, as women are left out of the real political dialogue.

Based on the above, families create new models of marital imperatives and censorship that result in a loss of control that the community eye exercised, monitoring and condemning violent behavior. The political invisibility of rural women makes the domestic space a conducive environment for the practice of violence (Segato, 2016). For this reason, the representation of rural women and the components of their social realities must be the basis for the creation of public policies for the prevention and eradication of gender-based violence, since violence interacts and reproduces itself through other forms of oppression such as race, socioeconomic status, birthplace, among others, and not only the universal concept of sex.

In recent decades, Latin America has seen significant regulatory advances in gender equality, placing structural violence against women high on the public agenda. In the case of Ecuador, this transformation is framed by the adoption of gender-focused public policies, in line with the Sustainable Development Goals of the 2030 Agenda, particularly goals 1 (no poverty), 5 (gender equality), and 10 (reduce inequalities). However, the results obtained in this research show that, despite these progressive regulatory frameworks and the State's adherence to international instruments such as CEDAW and the Belém do Pará Convention, gender-based violence persists at alarming levels, especially in rural areas.

Empirical evidence gathered in various studies shows that gender-based violence in rural Ecuador is not an isolated or temporary phenomenon, but rather a systematic manifestation of historically unequal power relations that subordinate women, violate their fundamental rights, and reproduce structural

exclusion. Data from the Survey on Violence against Women (INEC, 2019) show that in rural areas, 62.8% of women have suffered some form of violence.

These figures reveal not only the magnitude of the problem, but also the limitations of state action in guaranteeing a life free of violence for rural women. Based on the analysis of research such as that of Chiriboga Tapia et al. (2022) and Barraza et al. (2023), a series of structural and cultural barriers that perpetuate gender-based violence in rural contexts are identified.

These include the normalization of violent practices, social stigma towards women who report violence, lack of access to justice, health, and protection services, and the weak presence of the state in these territories. These findings coincide with the theoretical perspectives of Crenshaw (1989) and Segato (2003), who argue that gender-based violence must be understood from an intersectional and decolonial perspective.

In the Ecuadorian case, indigenous, montuvia, chola, peasant, and Afro-descendant women face multiple forms of oppression, which exacerbates their vulnerability. For her part, Segato argues that the female body in these rural contexts operates as a symbolic territory of domination, where violence is inscribed as a message of collective control.

Pérez-Martínez et al. (2024) and Barraza et al. (2023) collect testimonies from women who, driven by the desire to protect future generations, seek to transform cultural patterns internalized since childhood. However, these efforts do not always translate into effective public policies, due to institutional fragmentation, limited budget allocation, and low community participation in the design and implementation of state strategies, as noted by Cedeño et al. (2020) and Mendieta Lucas (2022).

On the other hand, the Comprehensive Organic Law to Prevent and Eradicate Violence against Women (LOIPEVM, 2021), although a significant step forward in terms of legislation, has been unevenly implemented, especially in rural areas.

Its effectiveness is hampered by factors such as the normalization of violence, institutional weakness, the invisibility of rural women in decision-making processes, and the lack of intersectionality in policy formulation. Hence the need to rethink traditional approaches to intervention, recognizing the voices of rural women as key actors in the design of sustainable strategies that guarantee a life free of violence.

Conclusions

In summary, the results of this research confirm the premise that public policies, although advanced at the regulatory level, have failed to bring about structural change due to weak implementation, institutional fragmentation, and low community participation.

In this sense, gender-based violence in rural areas of Ecuador responds to a complex network of structural, cultural, and institutional factors that make it persistent and deeply rooted. The low visibility of the phenomenon, impunity, and the normalization of violent practices reproduced in the family and community environment make it difficult to identify and eradicate. Despite the existence of regulatory frameworks and public policies with a gender focus, such as the LOIPEVM (2021), these are not effectively implemented in rural areas due to weak institutional presence, fragmentation of efforts, and poor adaptation to intersectional contexts.

Visualizing normative regulation at the same point of social acceptability as the center of a circle, and each social, economic, cultural, ethnic, gender identity, sexual preference, and ascribed status barrier that makes it more difficult for women to overcome gender inequality and those distances that occur within the same gender must be considered in everyday life.

Therefore, it is considered that power relations should be cross-cutting, where the circumference of the circle encompasses all the factors previously considered as social barriers (religion, ethnicity, economic status, political ideology, gender, sexual preferences, ascribed status, among others), considering that these social differences should not be a reason to stray from the center of "cultural values of each society" (ignoring values that perpetuate social injustice). This circumference is based on a model in which the axes of social differentiation are not factors that exclude interconnectivity with it.

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The use of task-based language teaching in promoting communicative competence

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Introduction

With globalization, there is a growing demand for graduates to possess strong oral communication skills in order to function effectively in both academic and professional settings. As a result, oral communication courses have been included in undergraduate programs. Despite this need and the various approaches to integrating oral communication skills into the curriculum, there seems to be limited research that offers a clearer understanding of the methods and strategies for teaching these skills to undergraduate students. Oral communication encompasses a broad range of activities, including formal presentations, teamwork, and participation in meetings. Language teaching has undergone a remarkable development in recent decades, driven by a deeper understanding of language acquisition processes and learners' communicative needs. In this context, Task-Based Language Teaching (TBLT) has emerged as a relevant pedagogical approach that seeks not only to cultivate language skills, but also to promote communicative competence among learners. Task-based language teaching (TBLT) focuses on the use of authentic language and asking students to do meaningful tasks using the target language (Chen, 2018; Gan & Leung, 2020).

This research is relevant in the current context of language teaching, where the need to develop effective communicative skills is increasingly crucial in a globalized and multicultural world. Understanding the role of TBLT in promoting communicative competence will not only enrich educational practice but will also contribute to the development of more effective strategies for language learning in the educational context (Barros & Sierra, 2025).

In today's global environment, the ability to communicate effectively in English is essential. However, traditional teaching methods often fail to develop the practical communication skills that students need. The application of Task-Based Language Teaching (TBLT) offers an opportunity to cultivate authentic and applicable communication skills in real-life situations. The context of the research is significant as it provides the opportunity to explore the effectiveness of TBL in promoting communicative competence within the specific educational environment in the academy Buckingham English Center.

Problematic Situation

The following research aims to analyze the impact of Task-Based Language Teaching (TBLT) on communicative competence, language teaching in the Ecuadorian context faces several challenges, among them the need to promote effective communicative competence among students. In this sense, the Task-Based Language Teaching (TBLT) approach emerges as a promising alternative to address this need.

This project focuses on highlighting the relevance and importance of conducting research on the impact of TBLT implementation on the communicative competence of English language learners. Oral presentation is seen as a motivating exercise that assists EFL Learners (EFLL) in their communication skills (Brooks & Wilson, 2014).

General Hypothesis:

The implementation of Task-Based Language Teaching (TBLT) in the last level at Buckingham English Center in Guayaquil, Ecuador, will have a positive impact on the development of students' communicative competence.

Specific Hypotheses:

1. Students exposed to TBLT will show greater progress in practical communicative skills, such as oral expression and listening comprehension, compared to those who follow a traditional approach to teaching English.

2. A significant difference will be observed in the results of the communicative competence tests between the experimental group (subjected to TBLT) and the control group, with better performance in the experimental group.

3. The students will perceive TBLT as a more effective and motivating methodology for developing communicative competence compared to traditional approaches to teaching English.

The results of this research had important implications for pedagogical practice and the formulation of educational policies in Ecuador. By demonstrating the benefits of TBLT in the development of students' communicative competence, it will be possible to design strategies and teacher training programs that promote more student-centered approaches focused on effective communication.

Communicative competence

Central to Communicative Language Teaching (CLT) is the concept of Communicative Competence (CC), which encompasses not only grammatical accuracy but also the ability to utilize language appropriately within various social contexts. Communicative Competence, a foundational principle in language education, emphasizes the effective and appropriate use of language across diverse social situations.

In teaching- Learning process communicative competence is part of speaking skill; this skill helps to communicate a message where the talker and receptor are linking connecting ideas and having interaction. According to Hymes (1972), communicative competence involves more than just knowing the rules of grammar and vocabulary. It also encompasses the ability to use language in specific social and cultural contexts, to understand and produce coherent and cohesive discourse, and to employ communication strategies when faced with language difficulties. In accordance to Ur (2000) stated that among the four language skills, listening, speaking, reading, and writing, speaking is considered the most crucial one.

Originally introduced by Dell Hymes in the 1970s, this concept was further refined by Canale and Swain (1980) expanded on the idea, suggesting a framework that encompassed four elements of communicative aptitude: grammatical proficiency, sociolinguistic proficiency, discourse proficiency, and strategic proficiency, these components provide a comprehensive framework for understanding effective communication.

Chomsky (1965) described linguistic competence as an idealized comprehension of a language's norms and construction. This encompasses the unique sounds employed in the language, their combination, the formation of phrases, and sentence interpretation. Once a speaker has mastered this set of norms, he or she can use it to create new phrases that all speakers of the same language will understand.

In response to Chomsky's concept of linguistic competence, American sociolinguist and anthropologist Dell Hymes invented the phrase "communicative competence" in 1967. He defines communicative competence

as "a member of society's ability to know when to keep silent, when speak, what code to use, where, when, and to whom," Hymes (1967). Since then, the term has evolved over time, and various models of communicative competence have been proposed by various scholars.

Two key models of Communicative Competence have been presented to explain and operationalize such a concept for educational purposes. According to Brown (2007), Canale and Swain's (1980) model of Communicative Competence contains four components: Grammatical competence is defined as "understanding of lexical elements as well as morphological, syntactic, sentence grammar semantics, and phonological rules." (Canale & Swain, 1980, p. 40); discourse competence, which accounts for the ability to connect sentences to build a coherent discourse into a meaningful whole (Brown, 2007); sociolinguistic competence, which relates to Hymes' social rules of language use. That is, every utterance is constructed within a socio-cultural framework that defines it. Finally, strategic competence, according to Canale and Swain (1983) refers to "the verbal and nonverbal communication tactics that may be used to compensate for communication disruptions" (p. 40-41). Speakers use this strategy to compensate for their lack of understanding of rules. (Savignon, 1997)

Use of task-based language teaching

The function of task-based language learning is to cultivate a natural desire among learners to enhance their language proficiency by engaging them in meaningful tasks. This pedagogical approach offers students the opportunity to actively participate in the language-learning process. In the classroom context, the primary emphasis is placed on the task itself, with language serving as the medium through which students achieve specific objectives. A task is defined as an activity in which learners utilize language to attain a defined outcome.

TBLT is a teaching approach that focuses on the use of language in meaningful tasks or activities, rather than just teaching grammar and vocabulary in isolation. It is a learner-centered approach that aims to develop communicative competence by engaging learners in tasks that simulate real-life situations.

Ellis (2003) states that Task-based learning offers the benefit of enabling students to utilize their existing skills, promoting language development through its application. Furthermore, it directs students' focus toward achieving a particular goal, where language acts as a tool and its application becomes crucial.

Research has shown that TBLT can be an effective method for promoting communicative competence in language learners (Willis & Willis, 2007). By engaging learners in tasks that require communication, TBLT allows them to

practice using the language in context, which can help them better understand and use the language in real- world situations.

Additionally, TBLT has been found to be effective in promoting language fluency, accuracy, and complexity (Skehan, 1998). This is because learners are forced to use the language in a more natural and spontaneous way, which can help them develop a more natural and fluent communication style.

Task-based learning (TBL) for foreign language instruction emerged in the 1990s as a progression of the communicative approach.

Barturén (2019) pioneered a pedagogical framework that structures classroom interaction around tasks, defining a task as a purposeful activity with a specific outcome, prioritizing the exchange of meaning over the production of specific language forms. This approach advocates language teaching through tasks that replicate real-life situations, encouraging student participation, communication, and cooperation during task performance.

According to Ayuso (2019), the goal of task-based learning is to provide learners with authentic contexts for language usage, as they engage in interactions in the target language while completing tasks.

According to Nunan (2004), task-based language teaching has strengthened as follows: 1) a need-based approach to content selection, 2) an emphasis on learning to communicate through interaction in the target language, 3) the introduction of the authentic texts into the learning situation, 4) the provision of opportunities for learners to focus not only on language but also on the learning process itself, 5) an enhancement of the learner's own personal experience as important contributing elements to classroom learning, and 6) the linking of classroom language learning with language use outside the classroom.

Some examples of tasks, as outlined by Nunan (1989), include:

- Organizing a party
- Describing the family.
- Organizing a trip.
- The city - tourist guide.
- Interviewing a foreigner.
- Talking about the routine of my favorite artist.

• Searching for solutions to couple's problems.

• Choosing the most useful inventions.

• Describing the preparation of my favorite dish, etc.

The beneficiaries of this study are students who are currently enrolled in a language course. The main characteristic of these students is that they are at a critical stage in their language learning journey where they need to develop and improve their communicative competence in the target language.

In this work, a quantitative approach will be adopted, involving the type of analytical research that requires two groups (experimental and control) for the comparison of variables that will help to prove or invalidate the main objective for the study, to determine the impact of task-based language teaching in promoting communicative competence among last level students. To collect data, a pre-test and a post-test will be employed to determine the impact of the investigation. Quantitative research uses numerical data and statistical analysis to investigate a research question or hypothesis (Babbie, 2016). Social sciences, education, and psychology often use it to study various phenomena, including academic performance, behavior, attitudes, and perceptions.

Qualitative methods aim to elucidate the co-construction of reality between the researcher and the participant, emphasizing a contextually rich understanding that captures the nuanced experiences of individuals. This approach not only enhances the depth of insights but also adheres to rigorous academic standards through its methodological foundations. Key components of this rigor include the trustworthiness criteria: credibility, dependability, confirmability, and transferability, which collectively ensure the integrity and robustness of qualitative research findings.

The introduction of the study delineates the core focus, aims, and rationale for exploring the utilization of Task-Based Language Teaching (TBLT) as an instructional approach to enhance communicative skills among last level students in Buckingham English Center. It commences by introducing TBLT as a method grounded in authentic and purposeful tasks, contrasting it with conventional methods that prioritize rote memorization of grammar and vocabulary. The primary aim of the research is to analyze the effects of implementing TBLT on students' communicative proficiency, underpinned by an extensive review of existing literature and empirical data collection.

This quasi-experimental research design is considered appropriate for this study, since it allows controlling for certain variables that could influence the results and establishing a causal connection between the independent variable and the

dependent variable. However, it is important to keep in mind that due to the quasi-experimental nature of the study, a definitive cause and effect relationship cannot be established, but significant patterns and trends between the variables analyzed can be identified (Galarza, 2021).

The sample is composed of 50 students from the last level of the Educational Unit. However, a distinction is made between the participants of the experimental group, which will be subjected to the proposed educational intervention, and the control group, which will not be subjected to the intervention with an additional variable.

Table 1. *Summary of the sample (Experimental group)*

Participants	Sample	Percentage
Males	13	52%
Females	12	48%
TOTAL	25	100%

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

Table 2. *Summary of the sample (Control group)*

Participants	Sample	Percentage
Males	10	40%
Females	15	60%
TOTAL	25	100%

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

Pre- test

The pretest results show significant differences between the experimental group and the control group in terms of the scores obtained. In the experimental group, the scores ranged from a minimum of 3 to a maximum of 6, with a mean of 4.52 and a standard deviation of 1.02. On the other hand, in the control group, scores ranged from a minimum of 4 to a maximum of 7, with a slightly higher mean of 5.552 and a standard deviation of 1.04. These figures suggest that, prior to the intervention, students in the experimental group presented a slightly lower level of communicative competence compared to the control group. However, the differences in means and standard deviations indicate that both groups were in similar skill ranges before the intervention.

Table 3. *Pretest results*

N	Lowest Score:	Highest Score:	Mean	St. Deviation
Experimental Group	3	6	4,52	1,02
Contol group	4	7	5,52	1,04

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

Post- test

The post-test results reveal significant changes in the scores of both groups after the intervention. In the experimental group, scores improved markedly, with a minimum of 6 and a maximum of 8, and a mean of 7, indicating a substantial increase in communicative competence. The relatively low standard deviation of 0.8 suggests that scores were clustered closer to the mean, indicating a consistency in the level of improvement among students. On the other hand, in the control group, although scores also varied, with a minimum of 4 and a maximum of 7, the mean was 5.32, showing less significant improvement compared to the experimental group. In addition, the higher standard deviation of 1.22 suggests greater variability in scores, which could indicate a heterogeneous response to the learning conditions. These results suggest that the TBLT- based intervention had a positive impact on the development of communicative competence in the experimental group compared to the control group.

Table 4. *Post-test results*

N	Lowest Score:	Highest Score:	Mean	St. Deviation
Experimental Group	6	8	7	0,8
Contol group	4	7	5,32	1,22

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

The results of the experimental group reveal significant progress in language skills after the TBLT intervention. On the pre-test, scores ranged from a minimum of 3 to a maximum of 6, with a mean of 4.52 and a standard deviation of 1.02. This indicates that, before the intervention, the students presented a variable level of communicative competence, with some gaps in linguistic knowledge. However, after the intervention, scores improved markedly, with a minimum of 6, a maximum of 8 and a mean of 7, with a lower standard deviation of 0.8. These results suggest that the TBLT intervention has been effective in improving the communicative skills of the students in the experimental group, as they have experienced a significant increase in their linguistic competencies, as reflected in higher scores and lower variability between scores.

Table 5. *General score of the pre-test and post-test: Experimental group*

N	Minimum	Maximum	Mean	St. Deviation
Pre-test	3	6	4,52	1,02
Post-test	6	8	7	0,8

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

The results of the control group show a different trend compared to the experimental group. On the pre-test, scores ranged from a minimum of 4 to a maximum of 7, with a mean of 5.52 and a standard deviation of 1.04. This indicates that, prior to any intervention, students in the control group already had a moderate level of communicative competence, with variability in their language skills. However, at post-test, scores remained in a similar range, with a minimum of 4, a maximum of 7, and a slightly lower mean of 5.32. The standard deviation also increased slightly to 1.22. These results suggest that, despite not receiving the TBLT intervention, students in the control group managed to maintain their level of communicative competence on the posttest, with minimal changes in their scores and slight variation compared to the pretest.

Table 6. *General score of the pre-test and post-test: Control group*

N	Minimum	Maximum	Mean	St. Deviation
Pre-test	4	7	5,52	1,04
Post-test	4	7	5,32	1,22

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

T- student test

The t-test is a statistical tool used to determine if there is a significant difference between the means of two independent groups. This test is based on Student's

t-distribution, which is a probability distribution that arises when estimating the mean of a population from a small sample. The t-test compares the difference between the means of two groups to the variability within the groups, taking into account the sample size.

Table 7. *T student Test*

Data	Experimental group	Control group
Mean Difference	2.48	-0.2
Standard Deviation of Differences	0.8	1.22
Sample Size (sqrt(n))	5	5
Standard Deviation of Average Differences	0.652	
t-value	4.11	
Critical t-value (**α**=0.05, df=24)	±2.064	

Note. Elaborated by Campoverde, Perez, Bonilla (2024).

Using these data, the student's t-test was conducted to compare the differences between the experimental and control groups before and after the intervention. Initially, the mean differences for each group were calculated. The experimental group exhibited a mean difference of approximately 2.48, whereas the control group showed a mean difference of approximately -0.2. Subsequently, the average difference between these mean differences was computed, resulting in 2.68.

Next, the standard deviation of the differences for each group was determined by the investigators, resulting in 0.8 for the experimental group and 1.22 for the control group. Using the square root of the sample size, a value of 5 was obtained for both groups. Then, the standard deviation of the average differences was calculated, yielding approximately 0.652.

Applying the formula for the t-test, the average difference was divided by the standard deviation of the average differences, resulting in a t-value of approximately 4.11. Upon comparing this value to the critical t-value for a significance level of **α** = 0.05 and df = 24, approximately ±2.064, it was found that the calculated t-value is significantly higher.

Based on the results obtained from the student's t-test, the null hypothesis is rejected for the present study. This indicates that there is statistically significant evidence to affirm that there is a significant difference between the groups being compared. Therefore, it can be concluded that the intervention or treatment

applied has had a significant effect on the variable of interest, suggesting a notable impact on the results.

Conclusions

The investigation into the effectiveness of implementing TBLT in developing practical communicative skills among last level English students has produced promising results. Through active student engagement in communicative tasks, significant improvements have been observed in their ability to effectively use English in real-life situations. This confirms the value of TBLT as a methodology for promoting the development of practical language skills.

Comparing progress in communicative competence between the experimental group, which underwent TBLT, and the control group following a traditional approach, significant differences have been observed. Students in the experimental group demonstrated greater advancements in oral fluency, listening comprehension, and interactive skills compared to those in the control group. This highlights the efficacy of TBLT in fostering enhanced communicative competence among English learners.

Both this study and prior research underscore the importance of speaking skills in language learning. The prioritization of speaking skills development among learners echoes the consensus in language acquisition research that speaking is a critical component of language proficiency, acting as both a tool for communication and a vehicle for cultural and social engagement (Rao, 2019).

In summary, this study confirms that the implementation of Task-Based Language Teaching (TBLT) has been successful in enhancing the communicative competence of students in the experimental group. Encouraging active use of English in real communication settings has led to significant progress in oral fluency, expressive ability, listening comprehension, and interaction in the language. Furthermore, integrated practice has effectively strengthened both vocabulary and grammar.

In Addition, this study enhances the existing prior research by offering empirical evidence regarding the efficacy of task-based learning in language acquisition. It specifically underscores the role of the participation in enhancing and promoting collaborative learning environments. By analyzing learners' preferences and their perceived advantages, this research provides actionable insights for language educators to develop more targeted and effective speaking activities that address the specific needs and challenges faced by learners in the language learning process.

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Theoretical and methodological basis of management with a focus on economic and financial management in private universities

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Introduction

University management, especially economic and financial management in private universities, faces growing challenges in a context of globalization, digital transformation, and demands for educational quality. The research question that guides this chapter is: How do the theoretical and methodological foundations of economic and financial management influence the sustainability and competitiveness of private universities? The objective is to analyze the management models applied, identify their main challenges, and propose strategies that strengthen institutional efficiency and transparency.

Throughout the chapter, key topics are addressed, such as the theoretical foundations of university management, administrative and economic-financial management models, and strategies for income diversification and digitization. Each section develops these aspects based on a documentary and comparative analysis, allowing for an understanding of the current situation and proposing innovative solutions.

The chapter contributes to scientific advancement by offering a comprehensive view of university management, highlighting the importance of strategic planning, transparency, and technological adaptation to ensure educational quality and financial sustainability. The conclusions presented guide institutions toward continuous improvement and the consolidation of their social function in a dynamic environment.

Fundamentals and dimensions of university management.

University management is a multidimensional field that encompasses the planning, direction, control, and evaluation of the processes that ensure the fulfillment of institutional objectives in higher education institutions (HEIs). In an increasingly competitive and globalized environment, universities face significant challenges related to educational quality, operational efficiency, and financial sustainability.

proposes an administrative model of university management that articulates "a logical scheme of management control applied in university education" (p. 1). This model focuses on measuring indicators by relevant dimensions, such as teaching and learning, satisfaction, internal and external activities, and income and costs, to evaluate quality and the fulfillment of institutional objectives.

The fundamental purpose of university management is to efficiently coordinate human, material, technological, and financial resources with the aim of improving institutional performance (Turpo and Pérez 2021). This management is based on principles of university governance, academic leadership, and strategic planning, which enable universities to fulfill their educational mission and contribute to the social and economic development of the country.

In order to measure university management, the author highlights the importance of the following indicators:

Teaching and learning: Quality of teachers, student opinion, graduation rate.

Satisfaction: Level of motivation of teachers and administrators.

External activities: Number of seminars and links with the community.

Revenue and costs: Diversification of funding sources (pp. 4-6).

From a structural perspective, university management can be divided into several key dimensions, of which we will mention:

Academic Management: Refers to the planning, development, and evaluation of educational programs, ensuring the quality of the teaching-learning process. Academic management should not only focus on the curriculum structure, but also on continuous adaptation to the changing needs of students and the labor market. In a globalized environment, it is essential that HEIs implement active and personalized methodologies that promote meaningful learning. This requires constant training of teachers in new pedagogies and technologies, as well as an institutional commitment to innovation (Andrey and Vargas, 2020).

Administrative Management: This involves the organization and supervision of internal processes that enable the efficient functioning of the institution. Administrative management is the heart that keeps an educational institution running. However, this management must go beyond mere supervision; it must be proactive and aligned with the institution's strategic objectives. The lack of a robust internal control system can lead to inefficiencies that affect both educational quality and student and staff satisfaction. It is essential to foster an organizational culture that values transparency and accountability.

Research and Outreach Management: Promotes scientific production and the university's relationship with society and the productive sector. The link between academia and the productive sector is crucial to ensure that research does not remain solely in the theoretical realm, but has a tangible impact on society. Universities must establish strategic alliances with companies and organizations to facilitate the exchange of knowledge and resources. This approach not only benefits students by providing them with practical experiences, but also contributes to the social and economic development of the environment in which they are inserted.

Economic and Financial Management: Ensures the economic sustainability of the institution through efficient administration of financial resources, generation of own income, and the search for external financing. Economic and financial management in HEIs must transcend resource administration to become a strategic axis that guarantees institutional sustainability and development. In a context of constant economic, social, and technological change, priority should be given to the adoption of process-based approaches that integrate strategic planning, internal control, and the use of technologies to optimize available resources.

University management in Ecuador is regulated by the Organic Law on Higher Education (LOES), which establishes the regulatory framework for the functioning of institutions and their administrative and academic processes.

Likewise, bodies such as the Higher Education Council (CES) and the Secretariat of Higher Education, Science, Technology, and Innovation (SENESCYT) play a crucial role in supervising and regulating the university system. In recent years, university management has evolved with the incorporation of digital technologies, quality methodologies, and participatory governance models that seek to improve operational efficiency and ensure transparent administration.

In this context, economic and financial management takes on particular relevance, as it allows universities to maintain their financial viability and respond to the demands of quality higher education.

Throughout this chapter, administrative management and economic and financial management will be addressed in greater depth as essential components of university management, analyzing their theoretical foundations, financing models, and resource optimization strategies.

Administrative Management Models in Public and Private Universities.

Administrative management in higher education institutions (HEIs) is a fundamental pillar for ensuring their efficient operation and the fulfillment of their academic and social objectives. This management encompasses the planning, organization, direction, and control of human, material, financial, and technological resources, with the aim of optimizing processes and improving educational quality. In a globalized and highly competitive context, HEIs face challenges such as digitization, accountability, and the need to adapt to the changing demands of society.

Administrative Management in State or Public HEIs.

Public HEIs operate under a strict regulatory framework, with mainly state funding and a strong focus on public service. Their administrative management is characterized by:

· **Dependence on public resources:** State universities are heavily dependent on government budgets, which limits their financial and operational flexibility.

This dependence can lead to delays in project implementation and difficulties in responding to emergencies or changes in the environment. · **Focus on equity and access:** Administrative management in these institutions prioritizes inclusion and access to higher education for vulnerable populations. However, bureaucracy and slow processes can hinder efficiency. · **Transparency and accountability:** Public HEIs are subject to rigorous audits and controls to ensure the proper use of public funds. While this promotes transparency, it can also create an excessive administrative burden.

Despite their commitment to equity, public HEIs face the challenge of balancing transparency with administrative agility. The lack of financial autonomy limits their ability to innovate and adapt to the needs of the labor market. Implementing reforms that simplify processes and promote efficiency without compromising the principles of inclusion should be considered a task to be undertaken.

Administrative Management in Private HEIs.

Private HEIs are distinguished by their financial autonomy and administrative flexibility, which allow them to adapt quickly to market demands. Their characteristics include:

- **Diversification of income:** These institutions generate resources through tuition fees, continuing education programs, and partnerships with the private sector, which gives them greater independence.
- **Agility in decision-making:** Not being subject to such strict state regulations, private HEIs can implement administrative changes more quickly, such as the adoption of digital technologies
- **Focus on competitiveness:** Administrative management is geared toward quality and profitability, which can translate into better infrastructure and student services.

However, this focus can also neglect social aspects

While flexibility is an advantage, private HEIs must ensure that the pursuit of profitability does not compromise educational quality and equity. The lack of regulation in some contexts can lead to opaque practices, such as excessive tuition increases. It is essential to find a balance between competitiveness and social responsibility.

Administrative Management in Private HEIs in Ecuador.

In Ecuador, private HEIs operate under the Organic Law on Higher Education (LOES), which establishes quality and transparency requirements. Their administrative management has the following characteristics:

- **Regulation and autonomy:** Although they enjoy autonomy, they must comply with regulations such as the submission of annually audited financial reports. This ensures a certain degree of transparency, but also generates administrative burdens.
- **Financial challenges:** Many private HEIs are overly dependent on tuition fees, which makes them vulnerable to fluctuations in student demand
- **Innovation and technology:** Some private universities have led the way in implementing ERP systems and digital platforms to optimize administrative processes

The main challenge for private HEIs in Ecuador is to reconcile profitability with educational quality. Although the LOES promotes transparency, its implementation has been criticized for limiting innovation. In addition, the lack of diversification in revenues could jeopardize the sustainability of these institutions in adverse economic contexts.

Economic-Financial Management and Institutional Sustainability.

Economic and financial management in higher education institutions (HEIs) is an essential strategic component for ensuring their sustainability and competitiveness. In a context of increasing globalization, digital transformation, and budgetary constraints, universities must implement strategies that guarantee the efficient use of their financial resources, contributing to the improvement of educational quality and the consolidation of their social function.

Elements and Functions.

Economic and financial management encompasses the preparation and execution of budgets, the diversification of income sources, the administration of expenses, and the implementation of internal control systems. These processes allow universities to plan for the short, medium, and long term, facilitating data-driven decision-making and ensuring transparency in the use of resources.

Proper financial management is based on three basic pillars:

- Budget Planning and Control: The preparation of realistic budgets and constant monitoring of their execution are essential to anticipate and respond to changes in the economic environment. The use of financial indicators allows performance to be measured and strategies to be adjusted when necessary.
- Revenue Diversification: Exclusive dependence on public funds can limit the operational capacity of HEIs.
  Therefore, it is essential that universities explore additional sources of funding, such as research projects, collaborations with the private sector, continuing education programs, and donations. This diversification not only strengthens financial viability but also stimulates innovation and institutional autonomy.
- Incorporation of Digital Technologies: Digital transformation has revolutionized the way financial resources are managed. Integrated information systems and digital management platforms allow real-time monitoring of financial flows, improving decision-making and promoting transparency. In addition, these tools facilitate process optimization and the reduction of operating costs.

Relevance in the International and Regional Context

At the international level, reports such as Education at a Glance 2021 highlight that universities that adopt modern and transparent economic and financial management practices have better performance and competitiveness indicators.

In this sense, the application of robust financial models translates into a greater capacity to face the challenges arising from global and local economic fluctuations.

In the context of Latin America, and specifically in countries such as Ecuador, the regulation and supervision of the financial management of HEIs is governed by national regulations. For example, the Organic Law on Higher Education (LOES) and the guidelines established by bodies such as the Secretariat of Higher Education, Science, Technology, and Innovation seek to strengthen the governance and transparency of economic and financial management in the university sector.

Challenges and Opportunities of Digital Transformation

The integration of information and communication technologies (ICT) into financial management is a trend that has gained relevance in recent years. The digitization of processes not only improves efficiency in the allocation and monitoring of resources, but also facilitates accountability and access to information, which are critical aspects in an environment of growing social demands.

Likewise, digital transformation contributes to strategic management by offering analytical tools that allow for real-time evaluation of the effectiveness of investments and detection of areas for improvement. This responsiveness is essential in a scenario where technological and economic changes are accelerating.

Impact on Quality and Sustainability

Well-structured economic and financial management has a direct impact on educational quality and the capacity of HEIs to innovate. The efficient use of financial resources enables investment in infrastructure, technology, research, and human capital development. This, in turn, translates into greater competitiveness and the university's ability to fulfill its social and educational mission.

In addition, diversifying sources of income and implementing robust internal control practices help mitigate risks and ensure that, even in periods of economic crisis, the institution can maintain its operations and continue to offer quality education.

In this vein, the present research divides higher education institutions into two categories: state or public HEIs and private HEIs.

Economic and financial management in state or public HEIs.

Economic and financial management in public HEIs is of crucial importance, as these institutions are responsible for administering resources from state funds and, in many cases, their own resources generated through various academic and outreach activities. The proper management of these resources not only ensures operational continuity but also influences the educational quality and social impact of public universities.

Specific Challenges for Public HEIs

State universities face particular challenges arising from their funding structure and social function. Among the most obvious challenges are:

Budgetary Constraints and State Dependency:

Public HEIs are heavily dependent on government budget allocations, which makes them vulnerable to changes in fiscal policy and budget cuts in times of economic crisis. This dependence can limit their ability to invest in infrastructure, technological innovation, and research programs. The need to optimize each allocated resource becomes imperative to maintain educational quality. This budgetary dependence urges public universities to seek mechanisms for efficiency and, at the same time, to diversify their sources of income so that they can reduce their vulnerability to government cuts. The incorporation of self-generating income strategies, such as offering continuing education courses or agreements with the private sector, can be key to strengthening their financial independence (González-Verjel et al., 2023).

Transparency and Accountability:

Given that public HEIs administer funds that come from state resources, the demand for transparency and accountability is greater than in the private sector. The implementation of internal control systems and the use of digital platforms for real-time monitoring of financial resources are essential tools for ensuring responsible management and preventing misappropriation or inefficient use of resources. Transparency not only strengthens the trust of society and regulatory bodies, but also acts as a driver for internal improvement. When the academic community has access to clear information on the allocation and use of resources, it fosters a participatory environment that can drive innovation in management and generate proposals for continuous improvement.

Need for Innovation in Financial Management:

Budget constraints and the growing demand for educational quality require public universities to adopt innovative approaches to the administration of their resources. The integration of information technologies, such as ERP (Enterprise

Resource Planning) systems and business intelligence tools, enables better planning, monitoring, and analysis of financial performance.

Technological innovation in economic and financial management not only modernizes internal processes, but also promotes an organizational culture oriented toward change and continuous improvement. This translates into a greater ability to anticipate financial problems and respond proactively to environmental challenges, thereby strengthening institutional resilience (Esquivel, 2018).

Pressure to Increase Educational Efficiency and Quality:

In the current environment, public HEIs are under pressure to demonstrate that the use of state resources contributes directly to improving educational quality. This implies the need to optimize resource allocation, identify inefficiencies, and redirect funds to strategic areas such as research, technological development, and human capital formation. Financial efficiency is an indicator of a university's ability to innovate and adapt. In this regard, the implementation of internal evaluation and audit systems can help identify areas for improvement, allowing institutions not only to maintain their viability but also to enhance their social and academic impact (Independent Auditors, 2023).

Challenges in Diversifying Revenue Sources:

Unlike private institutions, public HEIs tend to have less flexibility to generate alternative revenues. The search for complementary sources of funding—such as links with the business sector, externally funded research projects, or the implementation of outreach programs—becomes an essential strategy for diversifying financial risk and improving institutional autonomy. Income diversification is a strategy that, in addition to strengthening financial viability, promotes intersectoral collaboration and opens opportunities for knowledge transfer between the university and the productive environment. This not only favors innovation but also contributes to the consolidation of the social function of higher education.

Digital Transformation and Participatory Governance.

The incorporation of information technologies into the economic and financial management of public universities has emerged as an innovative solution to address the challenges described above. The use of integrated enterprise resource planning (ERP) systems and business intelligence tools facilitates budgeting, financial flow monitoring, and the generation of accurate reports that support strategic decision-making. Digital transformation in financial management not only optimizes internal processes but also strengthens participatory governance. By facilitating access to financial

information, it promotes greater involvement of the academic community in the decision-making process, which helps to build trust and improve accountability. This participation can drive the creation of more inclusive internal policies geared toward innovation in resource allocation.

Impact on Educational Quality and Sustainability.

Efficient economic and financial management in state institutions has a direct impact on the quality of higher education. The proper allocation of resources allows for investment in infrastructure, technology, research, and teacher training, which are essential elements for improving the teaching-learning process. Likewise, optimal resource management contributes to the long-term sustainability of universities, allowing them to adapt to economic and technological changes without compromising the quality of their programs. In this sense, transparency in management and accountability are fundamental elements that enhance the confidence of society and financial institutions, which in turn encourages greater investment in the education sector.

Economic and Financial Management in Private HEIs.

Economic and financial management in private higher education institutions is characterized by a high degree of autonomy and flexibility compared to state universities. This autonomy allows private HEIs to design financial strategies that respond quickly to changes in the environment and market demands, which translates into agile administration and the adoption of innovative financing models.

Financial Characteristics and Strategies.

Private higher education institutions enjoy greater autonomy in the management of their economic resources compared to state universities, for which we take into account the following aspects:

a) Financial Autonomy:

- Private Universities: These institutions generate their own income through tuition, fees, and other services. They do not depend on state allocations for their daily operations, which allows them greater flexibility in managing their resources. According to the National Institute of Statistics and Censuses, the private sector allocated a total of $1.3 billion to higher education, exceeding the $1.267 billion invested by the public sector.
- State Universities: Although they are autonomous in academic and administrative terms, they are heavily dependent on state funding. This dependence can limit their ability to make independent financial decisions and adapt quickly to economic changes. For example, in 2019,

public universities faced budget cuts that will affect their financial autonomy.

b) Flexibility in Resource Management:

- **Private Universities:** Not being subject to the same regulations and bureaucratic processes as public institutions, private universities can make financial decisions more quickly and adapt rapidly to the needs of the education market. This allows them to invest in infrastructure, technology, and academic programs more efficiently.
- **State Universities:** Resource management at public universities is influenced by government policies and administrative processes that can be slower and more restrictive. This can limit their ability to respond quickly to changes in the educational or economic environment.

c) Investment in infrastructure and academic quality:

- Private Universities: Financial autonomy allows them to invest in modern infrastructure, cutting-edge technology, and high-quality academic programs, which can result in a more competitive and attractive education for students. For example, in 2024, the University of the Hemispheres made economic adjustments to optimize its resources and maintain educational quality.
- **State Universities:** Dependence on state funds can limit the ability of public universities to make significant investments in infrastructure and academic programs, potentially affecting the quality of education they offer.

This autonomy allows them to design and implement their own financial strategies, adapted to market dynamics and the demands of their public objectives. In this regard, the following characteristics and strategies stand out:

Diversification of Revenue Sources:

Private HEIs do not depend exclusively on public funds; they supplement their resources through tuition fees, continuing education programs, research, consulting, strategic alliances with the private sector, and innovation projects. This diversification mitigates financial risk and expands the capacity for investment in infrastructure and technology. This capacity for diversification not only strengthens financial autonomy but also forces institutions to be proactive in seeking market opportunities. However, this commercial approach must be balanced with the educational mission to prevent the pressure for profitability from affecting the academic quality and social function of the university (Moreira and Mendoza, 2023).

Implementation of Information Technologies:

The adoption of integrated resource planning (ERP) systems and data analysis tools facilitates real-time monitoring of income and expenses, optimizing decision-making and improving administrative efficiency. Digital transformation in financial management allows private universities to respond quickly to changes in the economic environment. By incorporating advanced technology, these institutions can anticipate budget deviations and adjust their strategies based on accurate indicators. This practice not only improves operational efficiency but also enhances transparency and accountability, which are essential in a competitive environment.

Flexibility and Adaptability in Financial Planning:

Financial management in the private sector is characterized by flexible planning, which allows for rapid reorientation of strategies in response to changes in the market or student demand. This translates into the ability to respond quickly to emerging opportunities and economic crises without compromising quality standards. While flexibility is significant, it poses the challenge of maintaining a long-term strategic vision. The ability to adapt must be accompanied by evaluation mechanisms that ensure that changes in financial policy do not compromise the educational mission. It is essential that private institutions strike a balance between innovation and stability, ensuring that the pursuit of additional revenue does not lead to practices that could negatively affect educational quality.

Focus on Innovation and International Competitiveness:

Private HEIs invest in research projects, technological development, and postgraduate programs that allow them to position themselves in international rankings and attract both national and international students. This competitive orientation drives continuous improvement and innovation in academic offerings. The commitment to international competitiveness is a double-edged sword. On the one hand, it raises prestige and the ability to attract external resources; on the other, it can generate additional pressure to achieve outstanding financial and academic results. It is essential that internationalization strategies are integrated in a coherent manner with internal policies that ensure quality and social commitment, preventing the pursuit of positioning from translating into exclusionary practices (Marilú et al., 2024).

Economic and Financial Management in Private HEIs in Ecuador.

Economic and financial management in private higher education institutions in Ecuador is an essential component in ensuring their sustainability and educational quality. These institutions, operating under a private financing

model, depend largely on their own resources, which gives them significant autonomy in financial decision-making.

Regulatory Context and Regulatory Framework.

In Ecuador, private HEIs operate under a regulatory framework established by the Organic Law on Higher Education (LOES), enacted in 2010 and amended in 2018. This law defines the financial and administrative requirements that institutions must meet to ensure their operation and accreditation. According to Article 147 of the LOES, private HEIs must demonstrate financial solvency and submit annually audited financial reports. In addition, the Higher Education Council (CES) and the Higher Education Quality Assurance Council (CACES) are the bodies responsible for overseeing compliance with these regulations.

However, the application of these regulations has generated debate. On the one hand, it is argued that they guarantee transparency and educational quality; on the other, they are criticized for potentially limiting the financial autonomy of institutions and generating excessive administrative burdens. This duality reflects the tension between state regulation and the flexibility necessary for the efficient management of private HEIs.

Economic and financial management practices.

Economic and financial management in private HEIs in Ecuador focuses on resource optimization, income diversification, and investment in infrastructure and technology. According to a study by Torres and García, the main sources of income for these institutions include tuition fees, postgraduate programs, consulting services, and research projects. However, excessive dependence on tuition income makes them vulnerable to fluctuations in student demand.

In this regard, private HEIs have implemented strategies such as internationalization, the creation of strategic alliances, and the offering of online programs to diversify their income. However, these initiatives require significant investments and rigorous financial planning, which poses challenges for institutions with limited resources.

One of the main challenges of economic and financial management in private HEIs in Ecuador is the reconciliation of profitability and educational quality. Although it is essential to maintain financial sustainability, investment in research, innovation, and faculty development cannot be neglected. This dilemma is exacerbated in a context of increasing competition and high social expectations.

In addition, the lack of transparency in the financial management of some institutions has generated mistrust among stakeholders. According to a CACES report, some private HEIs have been sanctioned for non-compliance with

financial regulations, which affects their reputation and credibility. This underscores the need to strengthen control and accountability mechanisms.

Innovation, Digitalization, and Future Challenges in University Management.

Management models applied in state HEIs.

State or public HEIs generally have a working framework that is subject to strict regulatory frameworks and depend mainly on public funding. In Cuba, for example, the Economic-Financial Management Model (MGEF) of the Ministry of Higher Education (MES) is structured around systems such as planning, accounting, financial administration, and evaluation (SEAGEF), designed to guarantee minimum quality standards. This model prioritizes transparency and accountability through frequent audits, although it faces challenges such as bureaucracy and slow project execution due to its budgetary dependence. In addition, its centralized approach limits its adaptability to changes in the environment, which affects its ability to respond quickly to emerging demands.

In this vein, the author, in his article "Improvement of University Management Based on the Viable System Model. Case study: Universidad Libre," presents a novel methodology for HEI management, based on Stafford Beer's Viable System Model (VSM). This perspective, centered on organizational cybernetics, seeks to improve the viability, efficiency, and adaptability of HEIs through a systemic analysis that integrates only academic, administrative, and communication processes. Thanks to its application at the Free University, which is a private Colombian institution, it was possible to demonstrate the importance of flexible and participatory structures, where self-organization and feedback become fundamental pillars.

Management models applied in private HEIs.

On the other hand, private HEIs stand out for their financial autonomy and operational flexibility. The author demonstrates a model based on Strategic Functional Units (SFUs), which include finance, marketing, and service, with an emphasis on performance indicators such as student satisfaction and administrative efficiency (pp. 4-5). Analyzing this model, we can highlight that decentralized decisions can be made and rapid adaptation to market demands can occur, supported by technologies such as ERP systems. However, it faces the challenge of balancing profitability with educational quality, as the pressure to generate income can lead to social aspects being neglected.

Similarly, we review the case of the Free University of Colombia, which has adopted flexible and adaptive models to respond to the demands of the educational market. The analysis of this case highlights the application of

the **Viable System Model (VSM)** in this institution, which promotes self-organization, self-regulation, and administrative efficiency through recursive and participatory structures. This approach is based on the creation of working committees (executive, technical, and academic) that use *Experimentation-Action* methodologies to encourage collective reflection and organizational redesign.

Unlike state HEIs, private HEIs prioritize the **decentralization of processes**, the autonomy of academic subsystems, and the optimization of information flows to improve institutional competitiveness. However, the MSV applied at the Universidad Libre shows a critical limitation: the lack of explicit integration between **economic-financial management**and administrative processes, which hinders the strategic alignment of resources and long-term sustainability. This gap underscores the need for hybrid models that combine systemic adaptability with financial control tools, such as profitability metrics or results-based budgeting systems.

For a better understanding, the following comparative table shows the model applied, the main approach, financing, organizational structure, advantages, limitations, and respective examples. We can also see the integration between economic and financial management and administrative management (if any), the technologies used and the response to the environment are mentioned (Echeverri and Bravo, 2010).

A review of the literature reveals a gap in existing models: a lack of explicit integration between economic-financial and administrative management, especially in private universities. While the Cuban MGEF is rigid and centralized, the model prioritizes performance indicators without articulating interdepartmental coordination mechanisms. This limits synergy between key areas such as finance, administration, and academia. This independence demonstrates the underlying problem in university management: the lack of models that integrate the two types of management (economic-financial and administrative) to achieve comprehensive effectiveness. For example, in state HEIs, budgetary rigidity limits the implementation of pedagogical innovations, while in private HEIs, the absence of systemic financial planning can lead to imbalances between investments and academic results.

For an integrative model to be effective, it must combine or work simultaneously with the clarity and intervention of the MGEF and the adaptation and contribution of the MSV, incorporating:

a) Mechanisms in both directions that link economic-financial management and administrative management through administrative processes.

b) Hybrid indicators that measure both operational efficiency and economic sustainability.

c) Recursive structures that allow for real-time budget adjustments based on academic and administrative feedback.

This model is based on the premise that "economic and financial management must transcend operations and become a strategic axis that guarantees sustainability," aligning resources with the educational mission.

Conclusions

University management is a multidimensional field that encompasses planning, direction, control, and evaluation, the latter being the main differentiator from administrative management. University management carries out processes that guarantee the fulfillment of institutional objectives of HEIs through the principles of university governance, academic leadership, and strategic planning.

In order to fully comply with university management, the following division is observed: academic management, administrative management, research-linkage management, and economic-financial management.

Administrative management is one of the fundamental pillars that guarantees efficient operation and the fulfillment of academic and social objectives. This management encompasses the planning, organization, direction, and control of human, material, financial, and technological resources. Differences between public and private universities can be observed when analyzing administrative management. In the case of public universities, there is a dependence on public resources, a focus on equity and access, and transparency and accountability. In the case of private universities, we can mention the diversification of income, agility in decision-making, and a focus on competitiveness. According to this review, the particularities of administrative management in Ecuador's private universities were identified, such as regulation and autonomy, financial challenges, and innovation and technology. The challenge of reconciling profitability with educational quality remains.

Economic and financial management in higher education is a strategic component that ensures sustainability and competitiveness through the following basic pillars: budget planning and control, income diversification, and the incorporation of digital technologies. As with administrative management, economic and financial management varies greatly depending on where it is applied. In the case of state universities, we can mention budgetary constraints and state dependence, transparency and accountability, and the need for innovation in financial management. In the case of private universities, we have

financial autonomy, flexibility in resource management, and investment in infrastructure and academic quality. When reviewing economic and financial management in private universities in Ecuador, we find that it focuses on resource optimization, income diversification, and investment in infrastructure and technology, for which the following strategies are being applied: internationalization, creation of strategic alliances, and the offering of online programs.

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Structural conditions and technopedagogical practices in initial teacher education: a comparative study in Chile, Mexico, and Venezuela

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Introduction

Over the past decade, the integration of digital technologies into initial teacher education has emerged as a strategic priority in Latin American educational systems. This process, intensified by the COVID-19 pandemic, profoundly transformed educational dynamics, prompting a rapid shift toward virtual environments that tested not only technological infrastructure but also teaching capacities and institutional training policies. As Su (2023) points out, this shift impacted not only methodological practices but also the ways in which teachers construct their professional identity, requiring the integration of new technological competencies into their pedagogical framework.

However, this process has not been uniform. Structural conditions—such as access to connectivity, availability of equipment, prior training, organizational culture, and institutional support—largely determine how teachers appropriate and engage with digital technologies (Chen, Salleh, & Salleh, 2025). In fact, the literature indicates that when institutions fail to create supportive training environments or provide clear frameworks for guidance, resistance to technological innovation among faculty tends to intensify (Tomczyk, 2024).

This study aims to analyze how these structural factors influence the pedagogical decisions of university instructors responsible for training future teachers in three Latin American countries: Chile, Mexico, and Venezuela. The shared training experience—an online course on active methodologies mediated by technology—offers a valuable opportunity to explore how institutional, personal, and contextual conditions shape diverse trajectories of technopedagogical appropriation.

Adopting a qualitative and comparative approach, the study seeks to provide evidence on the challenges and opportunities involved in advancing toward a form of digital educational justice that is situated, contextualized, and sustainable in the region. In doing so, it contributes to understanding how structural conditions shape, enable, or limit technopedagogical practices, offering a comparative lens on how teacher educators in unequal contexts navigate digital transformation processes within initial teacher education.

Key Frameworks for Teacher Education in the Digital Era

The rapid advancement of digital technologies has transformed educational landscapes, demanding a critical review of the frameworks guiding teacher preparation. In this context, several key dimensions help illuminate the challenges, tensions, and opportunities surrounding teacher education in the digital age.

Digital Competence and Pedagogical Beliefs

Digital competence has become a central focus in both initial and continuing teacher education, especially in light of the accelerated integration of technologies in higher education. However, its conceptualization cannot be reduced to mere technical proficiency; it involves a critical, pedagogical, and context-sensitive integration of technology in real teaching environments (Su, 2023). From this perspective, digital competence emerges as a complex construct that weaves together technological, disciplinary, and pedagogical knowledge, aligning with the TPACK framework (Technological Pedagogical Content Knowledge), while also incorporating ethical, identity-based, and emotional dimensions that shape teaching practice (Backfisch *et al.*, 2024; Tomczyk, 2024).

In the Latin American context, recent studies highlight the importance of pedagogical beliefs as mediators of meaningful technology use in the classroom. Almerich *et al*. (2024) demonstrate that teachers' appropriation of technology depends not only on access to resources but also on their beliefs about the educational value of digital tools. Thus, digital competence should not be understood solely as a set of technical skills but as a situated practice that reflects the teacher's stance toward educational change.

Moreover, the development of such competencies is influenced by the pre-existing digital culture of both teachers and their students. As Chen, Salleh, and Salleh (2025) argue, sociotechnological trajectories, everyday practices, and prior experiences with virtual environments profoundly affect the pedagogical integration of ICT. In this sense, digital competence is constructed at the intersection of knowledge, prior experience, professional beliefs, and the structural conditions of the educational environment.

Teacher Professional Identity in Contexts of Digital Transformation

Teacher professional identity is a dynamic, situated, and relational construct shaped by individual, institutional, and sociotechnological factors. In contexts of rapid digital transformation—such as those experienced during and after the COVID-19 pandemic—this identity is challenged by new pedagogical demands, the intensive incorporation of digital technologies, and the need to redefine the

teaching role in virtual or hybrid environments (Su, 2023; O'Connor *et al.*, 2023).

Several studies have shown that the integration of technologies not only changes teaching practices but also affects how teachers perceive themselves as professionals (Backfisch *et al.*, 2024). Identity formation is influenced by the adoption of new methodologies, the development of digital skills, screen-mediated relationships with students, and the emotional management of technological uncertainty. The use of technology is not neutral—it can either strengthen or weaken professional confidence depending on the context, institutional support, and teachers' previous experiences.

In Latin America, this identity is forged amidst deep structural inequalities and ongoing demands for innovation. The digital culture of students—characterized by informal technological practices and expectations of immediacy—also shapes teacher identity, creating tensions between traditional school knowledge and the dynamics of the digital ecosystem (Marín *et al.*, 2025). Within this framework, professional identity is redefined not only through technical competence but also through pedagogical agency, ethical judgment, and the ability to construct educational meaning in uncertain contexts.

Models of Technological Integration

The integration of digital technologies into teacher education has given rise to various models aimed at understanding and guiding their pedagogical appropriation. One of the most widely adopted is the TPACK model (Petko, Koehler, & Mishra, 2024), which interrelates technological, pedagogical, and content knowledge to promote meaningful use of technology in the classroom. This approach has been enriched by more critical perspectives that stress the need to situate technopedagogical knowledge in real contexts, acknowledging the structural, emotional, and ethical dimensions of teaching (Backfisch *et al.*, 2024; Børte & Lillejord, 2024).

Recent studies have proposed more dynamic and context-aware models that move beyond instrumental approaches. Su (2023), for instance, proposes a framework for teacher competencies that includes not only technical skills but also sociocultural, affective, and relational dimensions—recognizing that the pedagogical use of technology is shaped by beliefs, identities, and institutional structures. In this sense, it becomes evident that knowing how to use tools is not enough; it is essential to develop a critical and reflective perspective on their use.

Furthermore, teachers' formative and professional experiences condition the type of technopedagogical integration that is achieved. Teachers' prior digital culture, collaborative practices, and cultural capital directly influence their

appropriation of technology in teaching (Cerda-Díaz, 2017). This suggests that integration models must be adapted to local realities and acknowledge the diverse trajectories of educators—especially in the unequal contexts present in many Latin American countries.

Within this framework, the most relevant models of technopedagogical integration are those that consider the complexity of the educational ecosystem and promote situated, critical, and context-responsive teacher training.

Structural Conditions and Inequalities in Latin America

The pedagogical use of digital technologies in teacher education is deeply conditioned by structural factors that go beyond teachers' willingness or individual preparation. In the Latin American context, such factors include the availability of technological infrastructure, stable internet connectivity, institutional support policies, public funding for higher education, and longstanding social inequalities that shape unequal access to training opportunities (Chen, Salleh, & Salleh, 2025; Marín *et al.*, 2025).

During the pandemic, these structural conditions became particularly visible, revealing a clear segmentation between institutions that were able to respond more effectively—thanks to consolidated networks, technical resources, and prior experience with online education—and others that faced serious challenges in delivering quality remote instruction (O'Connor *et al.*, 2023). These structural inequalities impacted not only access to technology but also the capacity to implement innovative, sustained, and meaningful pedagogical practices.

Moreover, public policies and institutional decisions play a key role. Su (2023) warns that without coherent institutional support and ministerial guidelines that promote a transformative digital culture, technology integration tends to remain superficial, fragmented, and dependent on isolated initiatives. This structural fragility often results in excessive burdens for teachers, further deepening inequality by shifting the responsibility for educational transformation onto individuals who may not have the necessary conditions to carry it out.

Available evidence suggests that although resilient and innovative efforts by teachers in adverse contexts do exist, these efforts cannot be sustained without digital equity policies, investment in infrastructure, institutional support, and context-specific professional development strategies. In short, structural factors are not merely a backdrop—they are determining elements that mediate the real possibilities for technopedagogical transformation in Latin America.

Access and Technological Conditions

The data reveals a clear disparity among countries. While Chile and Mexico reported relatively stable connectivity and institutional access to devices, Venezuela faced serious limitations. This is reflected in statements such as that of a Venezuelan educator: "At my university, internet connectivity is unstable and power outages are frequent; many students have to connect using their mobile phones with limited data" (Faculty, Venezuela).

By contrast, Chilean educators reported: "We have access to institutional platforms and hybrid classrooms, although technical support is not always available" (Faculty, Chile). These technological conditions directly influence the planning and sustainability of digital teaching strategies.

These findings reinforce the argument that structural factors—such as connectivity and infrastructure—are necessary but not sufficient conditions for the pedagogical use of digital technologies. As Chen, Salleh, and Salleh (2025) suggest, the mere availability of tools does not guarantee their meaningful integration; rather, digital access must be redefined as a pedagogical, ethical, and situated condition. In this sense, the disparities observed across Chile, Mexico, and Venezuela reveal how unequal infrastructural conditions constrain not only technical access, but also the pedagogical agency and identity formation of educators—especially when institutional support is lacking. This aligns with the critical frameworks of Backfisch *et al*. (2024) and Su (2023), who emphasize that the development of digital competence depends on the intersection between structural conditions, professional beliefs, and the capacity to exercise agency within specific contexts. Promoting digital equity, therefore, is not merely a matter of providing devices or connectivity, but of guaranteeing the conditions that enable transformative and context-aware technopedagogical practices.

Institutional Support and Internal Policies

The presence or absence of institutional policies supporting the pedagogical use of technology also marked significant differences. A Mexican faculty member noted: "Here, mandatory training has been implemented, and we receive recognition for participating in digital projects" (Faculty, Mexico), while in the Venezuelan case it was reported: "There is a lot of personal effort, but the institution lacks a clear policy; we do it because we believe in education, not because we have institutional backing" (Faculty, Venezuela). These accounts highlight the crucial role that teacher education institutions play in creating enabling conditions for technopedagogical integration.

This dimension aligns with the notion that professional identity and agency are

shaped by institutional culture and support (Su, 2023; O'Connor *et al.*, 2023). The presence of coherent policies, incentives, and recognition mechanisms not only facilitates engagement with digital tools but also contributes to the construction of a confident, empowered teaching identity. Conversely, the lack of institutional backing may exacerbate feelings of isolation and hinder innovation, reinforcing the necessity of robust institutional frameworks for sustainable digital transformation.

Continuing Education and Digital Culture

Despite contextual differences, participants from all three countries positively valued the shared learning experience provided by the virtual course. One Chilean educator expressed: "This course was an opportunity to update my skills and explore new ways of working actively with technology" (Faculty, Chile), while a participant from Venezuela stated: "I had never used Padlet or Canva in class. I learned a lot, although I needed help to connect" (Faculty, Venezuela). These experiences reflect the impact of contextually relevant training initiatives, even in precarious environments.

These accounts underscore the relevance of continuing education as a transformative driver of pedagogical change. As highlighted in the literature (Almerich *et al.*, 2024; Cerda-Díaz, 2017), professional development initiatives grounded in active, participatory, and context-aware learning models foster the development of meaningful digital competence. Furthermore, such experiences contribute to reshaping pedagogical beliefs and strengthening educators' confidence in navigating digital environments—both key elements in identity formation and technopedagogical appropriation.

Pedagogical Practices and Tensions

Faculty narratives revealed creativity and commitment, but also tensions between pedagogical aspirations and material constraints. In Mexico, one educator reported: "I tried virtual debates with my students using digital walls. It was a powerful experience, although it takes a lot of time to plan properly" (Faculty, Mexico). In Venezuela, a participant shared: "My students record audio and upload it when they have signal. It's a handmade approach, but it allows them to participate" (Faculty, Venezuela). These practices show that, even under adverse conditions, educators develop adaptive strategies to sustain pedagogical engagement through technology.

These findings illustrate the situated nature of pedagogical decision-making in contexts of technological precarity. The capacity to improvise and adapt, while often viewed as a reactive measure, can also be interpreted as a form of pedagogical agency grounded in ethical commitment and contextual

understanding (Børte & Lillejord, 2024). This reinforces the need to conceptualize digital teaching not merely in technical terms, but as a practice embedded in identity, values, and professional judgment—particularly in environments marked by systemic inequality.

Conclusions

This qualitative study confirms that the pedagogical integration of digital technologies into initial teacher education in Latin America is deeply conditioned by structural factors that go beyond individual competencies. Elements such as the quality of internet connectivity, availability of technological resources, institutional support, and opportunities for continuing professional development shape an ecosystem that can either enable or constrain technopedagogical transformation.

The findings reveal that structural conditions—while highly unequal across the cases of Chile, Mexico, and Venezuela—play a decisive role in shaping how university instructors make pedagogical decisions regarding the use of technology. In countries where institutional support and digital infrastructure are more robust, instructors are more likely to engage in innovative, sustained, and reflective practices. In contrast, in contexts of greater precarity, such as Venezuela, pedagogical decisions are frequently limited by infrastructural instability, lack of support, and the need for improvisation. Nonetheless, across all three countries, educators demonstrated a resilient, creative, and ethically driven commitment to their role in preparing future teachers.

Importantly, participants' narratives indicate that "access" must be understood not only in technical terms, but as the capacity to critically and contextually appropriate technologies within their teaching practice. This appropriation is contingent upon coherent institutional policies, sustained support systems, and training spaces that are responsive to the lived realities of educators in each national context.

The collective experience of the course "Active Methodologies in Virtuality", which was positively valued across contexts, underscores the potential of collaborative and action-oriented training models to foster reflective pedagogical practices even in challenging conditions. This highlights the importance of designing learning experiences that are not only technologically enriched, but also socially and institutionally grounded.

In light of these findings, it is recommended that teacher education institutions: a) Systematically integrate continuing education opportunities in digital technologies, grounded in a situated and active learning approach; b) Strengthen digital infrastructure and provide consistent support for faculty in

virtual and hybrid learning environments; c) Formally recognize digital teaching efforts through institutional incentives and mechanisms of support; d) Promote communities of practice to facilitate the exchange of context-specific pedagogical strategies, experiences, and resources.

Ultimately, this study reaffirms that educational justice in the digital age must not be considered apart from the structural conditions that define teachers' possibilities for action. Digital equity—understood as the guarantee of real opportunities for access, use, and pedagogical appropriation of technology—should be a central axis of public policy and a cornerstone of teacher education models across Latin America. In doing so, the study sheds light on how structural disparities across Chile, Mexico, and Venezuela shape not only access to digital tools, but also the pedagogical agency, decisions, and identity formation of the university educators who prepare the next generation of teachers.

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Organizational innovation and competitive sustainability in family businesses: Global bibliometric analysis and strategic perspectives for Latin America and Ecuador

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Introduction

Organizational innovation is a key strategic factor in the dynamics of contemporary companies.

In a global environment characterized by rapid digital transformation, high economic volatility, and growing pressure for sustainability, organizations face the challenge of rethinking not only their products and processes, but also their internal structures, management models, and ways of interacting with markets and communities (Tidd and Bessant, 2013). The ability to transform organizational practices, introduce new governance schemes, and adapt work systems is critical to achieving sustainable competitive advantage.

According to the Organization for Economic Cooperation and Development (OECD, 2018), organizational innovation involves implementing new administrative practices, restructuring responsibilities, improving decision-making processes, and incorporating changes in strategy that enhance organizational efficiency and effectiveness. These changes not only strengthen companies' adaptability, but also amplify their potential for strategic differentiation, resilience to crises, and long-term value creation (Teece, 2018).

Family businesses, which represent between 70% and 90% of the business fabric in many regions, play a fundamental role in the global economy, particularly in Latin America (Turpo and Pérez, 2021). However, they have specific dynamics that condition their capacity for organizational innovation. While their strong long-term orientation, family values, and emotional commitment to the business can act as catalysts for innovative processes (Chirico and Salvato, 2008), factors such as resistance to change, intergenerational conflicts, and traditional

management models can significantly limit their capacity for organizational transformation (Cruz and Nordqvist, 2012).

A critical analysis of the literature shows that, despite growing interest in the relationship between innovation and family businesses, significant gaps remain. Most existing studies focus on developed economies and tend to address innovation from technological or product perspectives, relegating organizational innovation as a strategic driver of competitiveness to the background. Furthermore, there is limited coordination between studies on innovation, business models, business sustainability, and family governance, which hinders a comprehensive understanding of the factors that enable family businesses to maintain their long-term competitiveness in changing environments.

In Latin America, and particularly in Ecuador, this situation is even more critical. Family businesses represent more than 90% of productive units (INEC, 2023) and are a fundamental axis for job creation and economic stability. However, they face significant barriers to institutionalizing organizational innovation practices that strengthen their strategic resilience. Informality in management processes, the concentration of power in founding figures, poor succession planning, and restrictions on access to strategic resources limit their ability to adapt to the demands of increasingly competitive and dynamic markets.

This reality highlights the need to strengthen academic research on the factors that link organizational innovation with competitive sustainability in the context of family businesses in emerging economies. It is necessary to overcome fragmented approaches and generate analytical frameworks that allow for an understanding of the internal dynamics of innovation, its institutionalization processes, and its effects on long-term business continuity and success.

Within this framework, the overall objective of this study is to map, interpret, and visualize the conceptual evolution of the scientific literature related to organizational innovation, business models, sustainable competitive advantage, and business sustainability, particularly in the context of family businesses. To achieve this purpose, we propose to analyze the annual scientific output in the field of study, identify the most relevant actors in terms of authorship and academic dissemination, detect conceptual nuclei through the analysis of keyword co-occurrence, visualize the evolution of emerging themes through structural and density maps, and critically interpret the main semantic relationships that shape the contemporary academic discourse on innovation, competitiveness, and sustainability in family businesses.

The relevance of this analysis lies not only in offering a systematization of the state of knowledge, but also in highlighting opportunities for future research

aimed at strengthening the organizational capacities of family businesses in highly volatile contexts and boosting their sustainable competitiveness in regional environments with particular socioeconomic dynamics.

The research question that guides this study is: How has the global scientific literature on organizational innovation and competitive sustainability in family businesses evolved, and what are the specific characteristics for Latin America and Ecuador? The specific objectives of this chapter are: to identify global patterns and trends in scientific production related to these topics; to comparatively analyze how they have been addressed in different geographical contexts, especially in Latin America and Ecuador; and to offer concrete strategic recommendations adapted to emerging realities.

Global conceptual framework on organizational innovation and competitive sustainability in family businesses

Organizational innovation refers to the introduction of significant changes in an organization's internal structure, administrative processes, work practices, or external relationships, with the aim of improving its performance and adaptability (OECD, 2018). Unlike product or process innovation, which tends to focus on immediate tangible results, organizational innovation transforms the internal capabilities of the company, favoring the creation of an environment conducive to the continuous generation of value. Tidd and Bessant (2013) emphasize that organizational innovation acts as a cross-cutting enabler: without changes in the way work is organized, decisions are made, or knowledge is managed, other forms of innovation are difficult to sustain. This type of innovation involves, among other things, the implementation of new governance systems, the professionalization of management, the creation of multidisciplinary teams, and the adoption of organizational cultures open to experimentation.

In the context of family businesses, where informal authority dynamics, emotional loyalties, and inherited structures prevail, organizational innovation is particularly challenging (Gersick et al., 1997). However, various studies (De Massis et al., 2018) show that family businesses that manage to introduce strategic organizational changes—for example, separation of ownership and management, creation of family councils, or definition of succession protocols—tend to achieve higher levels of resilience, adaptability, and sustainability in the market. In short, organizational innovation is the fundamental input that allows family businesses not only to adapt to changes in the environment but also to transform their strategic proposal to generate sustainable competitive advantages.

Based on this conceptual foundation, it is essential to analyze how organizational innovation acts as an enabler of innovation in the business model, redesigning

the way family businesses create and capture value. This perspective allows us to understand how organizational changes enable structural transformations that affect the value proposition and the company's interaction with its environment.

Business model innovation involves redesigning the logic with which a company creates, delivers, and captures value (Osterwalder and Pigneur, 2010). Unlike incremental or technological innovations, innovating in the business model involves structural changes in key aspects such as the value proposition, customer segments, distribution channels, revenue sources, and strategic relationships. Teece (2010) argues that business model innovation represents a distinctive source of competitive advantage, particularly in environments where technological innovation has become commoditized. A company that succeeds in modifying its business model can redefine the rules of the market, capture new opportunities, and establish competitive barriers that are difficult to imitate.

In the case of family businesses, innovating in the business model requires, as a precondition, organizational innovation that facilitates openness to new ideas, professional risk management, and the institutionalization of strategic decision-making processes (Zott et al., 2011). Thus, organizational innovation not only precedes but also enables innovation in the business model, allowing family businesses to evolve beyond their founding legacy toward more adaptive and sustainable models.

Understanding how organizational innovation and business model innovation are linked leads to exploring how these transformations contribute to building sustainable competitive advantages that transcend market dynamics. When analyzing these transformative processes, it is essential to consider the concept of sustainable competitive advantage, an element that articulates and gives meaning to the relationship between innovation and business success.

Sustainable competitive advantage was formulated by Barney (1991) as a situation in which a company possesses resources and capabilities that are valuable, rare, imperfectly imitable, and organizationally exploitable (VRIO framework). This advantage is not limited to temporary success but is maintained over time despite competitors' efforts to neutralize it.

In the context of organizational innovation, various studies (Wang and Ahmed, 2007; López-Cabarcos et al., 2015) have shown that the ability of organizations to innovate internally—through changes in processes, structures, and cultures—correlates positively with the attainment of sustainable competitive advantages. Organizational innovation helps strengthen a company's dynamic capabilities, that is, its ability to integrate, build, and reconfigure internal and external competencies in response to changes in the environment.

In family businesses, building sustainable competitive advantages often faces particular challenges: dependence on a founding generation, resistance to change, and intergenerational conflicts. However, those that manage to innovate organizationally tend to develop successful succession mechanisms, greater resilience to crises, and a strong organizational identity, all of which are factors that fuel their long-term competitive advantage.

This analysis is complemented by a view of family businesses as key players in the global economy, where sustainability is not only a financial goal, but also a cultural and social one. Finally, it is important to contextualize these processes within the particular characteristics of family businesses and their link to sustainability as a cross-cutting issue. Family businesses are an essential pillar of the global economy, representing between 70% and 90% of businesses in most countries (Family Firm Institute, 2023). Beyond their economic weight, these organizations have cultural and structural characteristics that profoundly influence their dynamics of innovation and sustainability. One of the distinctive features of family businesses is their long-term orientation and concern for intergenerational continuity (Miller and Le Breton-Miller, 2005). This time horizon, while it can be a driver of resilience, can also act as a brake on innovation if the company becomes entrenched in traditional practices.

The concept of sustainability in family businesses is not limited to economic performance; it integrates social (legacy, community responsibility) and environmental (preservation of resources for future generations) dimensions. Recent research (Bammens et al., 2011; De Massis et al., 2018) has shown that family businesses tend to adopt innovations that reinforce their social legitimacy and reputation, beyond their immediate profitability. Thus, organizational innovation in family businesses not only seeks to improve internal efficiency or adapt to the market, but also to preserve and project family values across generations, within a framework of economic, social, and environmental sustainability.

The conceptual framework presented establishes the basis for understanding how organizational innovation in family businesses acts as a strategic vector that enables transformations in the business model, promotes the construction of sustainable competitive advantages, and facilitates intergenerational continuity and legitimacy in dynamic environments. These interrelated concepts will guide the bibliometric analysis and structure the discussion of the results of this study.

Bibliometric mapping of innovation and sustainability in family businesses

This research adopts an exploratory quantitative approach based on bibliometric analysis techniques. The main objective was to map, interpret, and visualize the conceptual evolution of scientific literature related to organizational innovation,

business models, sustainable competitive advantage, and business sustainability, especially in the context of family businesses.

The use of bibliometric analysis was justified by its ability to identify publication patterns, semantic co-occurrence networks, thematic clusters, and emerging trends, which are essential for substantiating theoretical and strategic proposals adapted to real organizational environments.

A non-experimental, cross-sectional, and retrospective design was chosen, based on the mining of secondary academic data from a specialized source. The methodological strategy focused on: analyzing annual scientific output; identifying key actors: authors, sources, and relevant countries; detecting conceptual nuclei through keyword co-occurrence; visualizing the evolution of topics through conceptual and density maps; and interpreting the semantic relationships that underpin the articulation between innovation, competitiveness, and sustainability in family businesses. This combination allowed us to construct an integrative and critical view of the field of study.

Collection and refinement of the corpus

Data collection was carried out in the Scopus database, renowned for its editorial rigor and extensive international coverage in the social sciences, economics, and business management.

The search strategy used the following advanced equation, applied in the TITLE-ABS-KEY fields:

(TITLE-ABS-KEY((“organizational innovation” OR “business model innovation” OR “social innovation”) AND (“competitive advantage” OR “sustainable competitiveness” OR “strategic advantage” OR “business performance” OR “resilience” OR “differentiation” OR “governance” OR “succession planning” OR ‘sustainability’ OR “institutional legitimacy” OR “adaptability”) AND (“family business” OR “family-owned business” OR “family firm” OR “SME*” OR “entrepreneur*”)) AND PUBYEAR > 2013 AND PUBYEAR < 2025) AND (LIMIT-TO(SUBJAREA, “BUSI”) OR LIMIT-TO(SUBJAREA, “SOCI”) OR LIMIT-TO(SUBJAREA, ‘ECON’)) AND (LIMIT-TO(DOCTYPE, “ar”))

Inclusion criteria: Peer-reviewed articles published between 2014 and 2024; documents addressing at least one of the following topics: innovation, competitiveness, sustainability, or family business; and written in English or Spanish. Exclusion criteria: Duplicate, incomplete, or irrelevant works; and articles focused exclusively on medical areas or technical engineering unrelated to organizational management. The final corpus consisted of 384 scientific documents.

Analysis techniques and tools

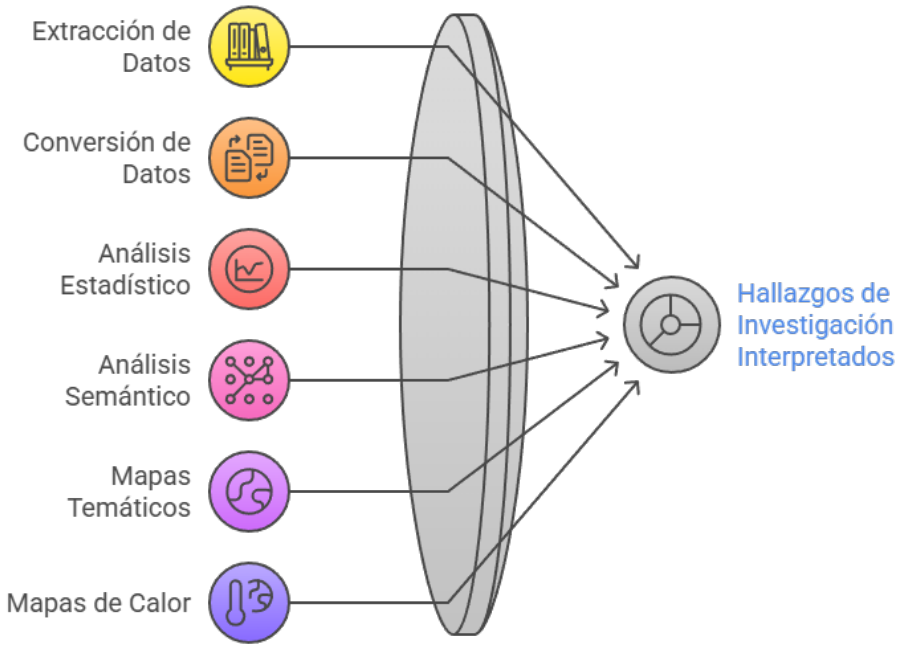
The bibliometric analysis was performed using the RStudio ecosystem, through the following tools: Bibliometrix: Specialized package for the processing, cleaning, and statistical analysis of bibliographic data (Aria and Cuccurullo, 2017); Biblioshiny: Bibliometrix graphical interface that facilitated the generation of dynamic graphs and thematic maps; and VOSviewer: Software used to build co-occurrence networks and visualize semantic density maps, highlighting highly topical concepts by means of yellow zones.

The specific techniques applied included: Descriptive analysis of annual production, average citations, most relevant sources, and authors; Co-occurrence analysis of keywords (Author Keywords) to identify thematic clusters; Thematic analysis to categorize topics according to their density and centrality; Generation of heat maps to visualize emerging trends and current central concepts.

Analysis procedure

The methodological procedure follows the steps shown in Figure 1:

Figure 1. *Bibliometric analysis process: from data extraction to interpretation of research findings.*



Note. Own elaboration.

The methodological procedure followed in this study ensured a comprehensive and systematic analysis of the relevant scientific literature. Initially, data was

extracted in CSV format from the Scopus database, followed by conversion and cleaning of the bibliographic file using the *convert2df()* function of the Bibliometrix package in RStudio. Subsequently, a basic statistical analysis of the corpus was performed, which allowed for the characterization of annual scientific production, the most productive authors, and the most relevant sources, establishing a solid basis for subsequent conceptual analysis.

At the semantic level, keyword co-occurrence networks were constructed to identify the main thematic connections, and thematic maps were generated that classified the topics into driving, specialized, emerging, and declining areas. In addition, a heat map was developed using VOSviewer, which allowed for intuitive visualization of the relevance and intensity of central concepts, such as organizational innovation, business models, competitive advantage, and sustainability. Finally, a critical interpretation of the findings was carried out in accordance with the objectives set, thus ensuring a deep and articulated understanding of the conceptual dynamics of the field.

Ethical and scientific considerations

The research was based on the use of secondary sources with institutional or public access. No human subjects or personal data were involved, in accordance with current academic ethics standards. The traceability of the data and transparency in processing guarantee the reproducibility of the results obtained.

Validity and reliability

To ensure the scientific quality of the study, explicit criteria of validity and reliability were incorporated. Content validity was strengthened through the rigorous construction of the search equation, based on recognized theoretical frameworks such as the Oslo Manual (OECD, 2018) and the Global Innovation Index (WIPO, 2024). The relevance of the terms used ensures that the corpus effectively responds to the object of study.

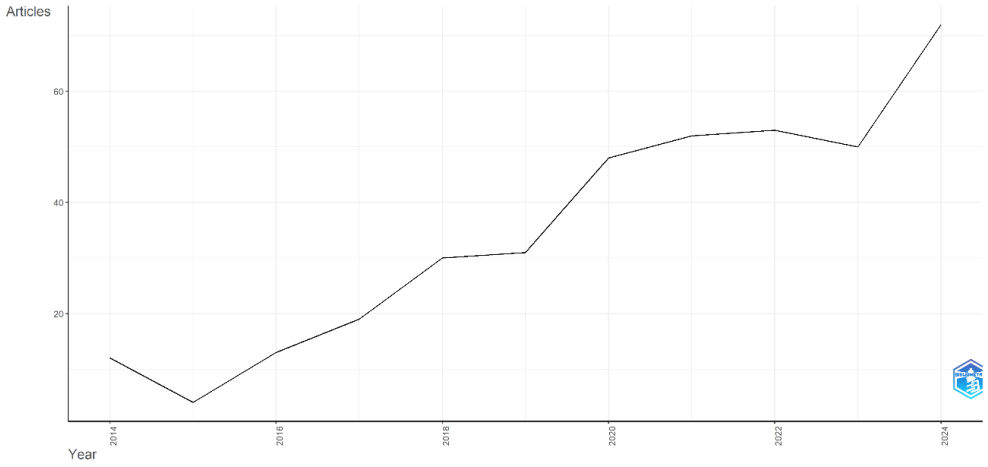
External validity was ensured by selecting Scopus as the data source, given its international recognition and rigorous editorial review system. Structural validity was achieved through the triangulation of analysis techniques (co-occurrence, thematic maps, and heat maps), allowing for an objective representation of the conceptual configuration of the field under investigation.

With regard to reliability, the use of established bibliometric tools such as Bibliometrix, Biblioshiny, and VOSviewer ensured the stability of the analytical procedures. All processes are replicable and standardized, following best practices in scientific information analysis. Taken together, these elements reinforce the methodological soundness of the study, allowing the results obtained to be considered valid, reliable, and transferable.

Main results

The evolution of scientific production in the field of organizational innovation, sustainable competitive advantage, business models, and family businesses during the period 2014–2024 reflects a steady growth in academic interest in these topics (see Figure 2).

Figure 2. *Annual scientific output on organizational innovation, business models, competitive advantage, and sustainability in family businesses (2014–2024).*



Note. Prepared by the authors based on Biblioshiny - Scopus Dataset.

Analysis of annual document output shows an average growth rate of 19.62% in the number of publications. This behavior is indicative of the progressive consolidation of a field of research that, until recently, was fragmented among various disciplines such as strategic management, business innovation, and family entrepreneurship.

During the early years of the period analyzed (2014–2017), production remained relatively stable, with moderate publication volumes. However, since 2018, there has been a notable increase in the number of articles published annually, a phenomenon that can be associated with several global dynamics: the acceleration of digital transformation in organizations, the rise of studies on business resilience and post-economic crisis sustainability, as well as the need for family businesses to adapt to highly volatile and uncertain environments.

In particular, 2020 and 2021 show a slight decline, attributable to the initial impact of the COVID-19 pandemic on research activity and academic publishing processes worldwide. However, from 2022 onwards, the trend returns to significant growth, suggesting a revitalization of interest in the study of innovation and sustainability as critical factors for business survival and success in contexts of crisis and economic recovery.

This evolutionary pattern not only confirms the thematic relevance of the proposed research, but also evidences a progressive maturation of the field, where the concepts of organizational innovation, business model reconfiguration, sustainability, and sustainable competitive advantage have become strategic axes for academia and contemporary business practice.

The observed growth empirically supports the relevance of in-depth analysis of the interrelationships between these constructs, especially in the context of family businesses, a sector that represents a substantial part of the business fabric in emerging economies such as Ecuador.

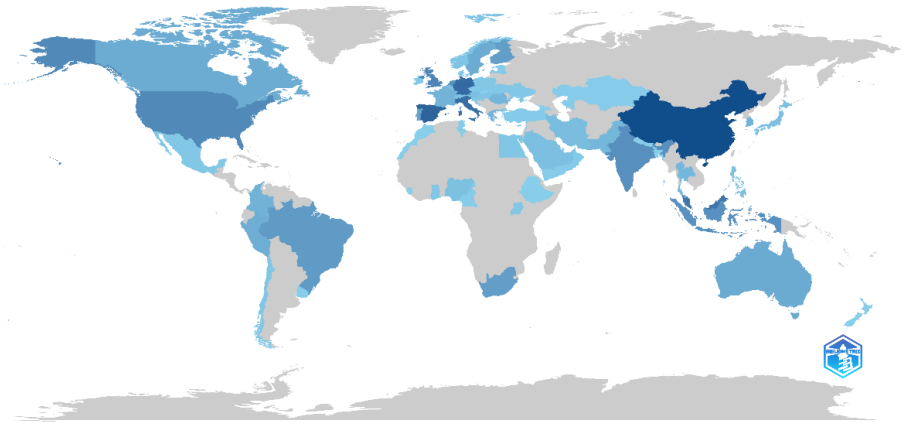
The upward trend in scientific output over the last ten years confirms that organizational innovation, business models, sustainability, and competitiveness have become areas of growing interest in academic research. However, to fully understand the development of this field, it is not enough to analyze only the temporal dynamics of publications; it is also essential to consider the geographical distribution of research efforts. The location of scientific output allows us to identify centers of excellence, regional dynamics of knowledge generation, and potential gaps between leading and emerging regions.

Analysis of scientific output by country reveals a significant concentration in certain regions of the world, especially North America, Western Europe, and East Asia. The United States and China lead by a wide margin in terms of publication volume, followed by the United Kingdom, Germany, and Australia. This concentration suggests that much of the theoretical and practical progress on organizational innovation and sustainable competitive advantage is generated in highly developed economies, where investment in business research and development is substantial.

In contrast, Latin America, although it has a modest share in absolute terms, shows an upward trend in countries such as Brazil, Mexico, Colombia, and Chile. This emerging trend in the region reinforces the importance of promoting studies that contextualize innovation and sustainability in family businesses within the socio-economic realities of transition economies.

The particular case of Ecuador, with its still incipient production in this field, highlights the need for research such as this, which seeks to strengthen local knowledge and promote strategic proposals adapted to its business structure. Figure 3 summarizes the geographical distribution of the scientific output analyzed.

Figure 3. *Scientific output by country on organizational innovation, business models, competitive advantage, and sustainability in family businesses (2014–2024).*



Note. Prepared by the author based on Biblioshiny - Scopus Dataset.

Based on this spatial characterization of knowledge, it is pertinent to examine in greater detail the properties of the corpus of selected documents, analyzing their general characteristics, such as the number of citations, the age of the publications, and the diversity of academic sources.

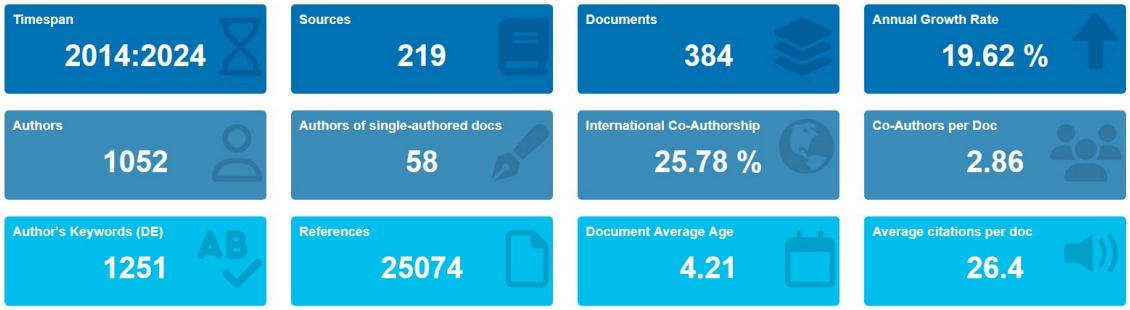
Understanding the spatial dynamics of scientific production provides an initial approach to the territories where knowledge about organizational innovation and sustainable competitive advantage is generated. However, to consolidate a more comprehensive view of the field, it is essential to systematically characterize the set of documents that make up the analysis corpus. This characterization allows us to assess aspects such as thematic maturity, the impact of scientific production, and the diversity of editorial sources that support the observed trends.

The descriptive analysis reveals that the set of 384 scientific articles examined has an average age of 4.21 years, which shows that it is predominantly recent literature, with a strong concentration of research published in the last five years. This data reinforces the perception that the study of organizational innovation and its connection to sustainability and business competitiveness is a rapidly expanding phenomenon, both theoretically and empirically.

In terms of impact, the corpus has an average of 8.72 citations per document, reflecting a moderate level of academic influence in the areas of management and entrepreneurship. Likewise, the articles were disseminated through 260 different sources, which denotes considerable editorial diversity and confirms

the cross-cutting nature of the subject matter. Figure 4 summarizes the main descriptive metrics that characterize the analyzed data set.

Figure 4. *General information on the corpus: documents, citations, sources, and average age of publications (2014–2024).*



Note. Prepared by the author based on Biblioshiny - Scopus Dataset.

The breadth and heterogeneity of the editorial sources observed not only demonstrate the cross-cutting nature of the field, but also reveal the existence of some centers of knowledge generation that are more active than others. Identifying the journals and researchers that have produced the most significant output is essential to understanding the dynamics of academic legitimation, as well as the flows of knowledge construction and transfer around organizational innovation, sustainability, and business competitiveness.

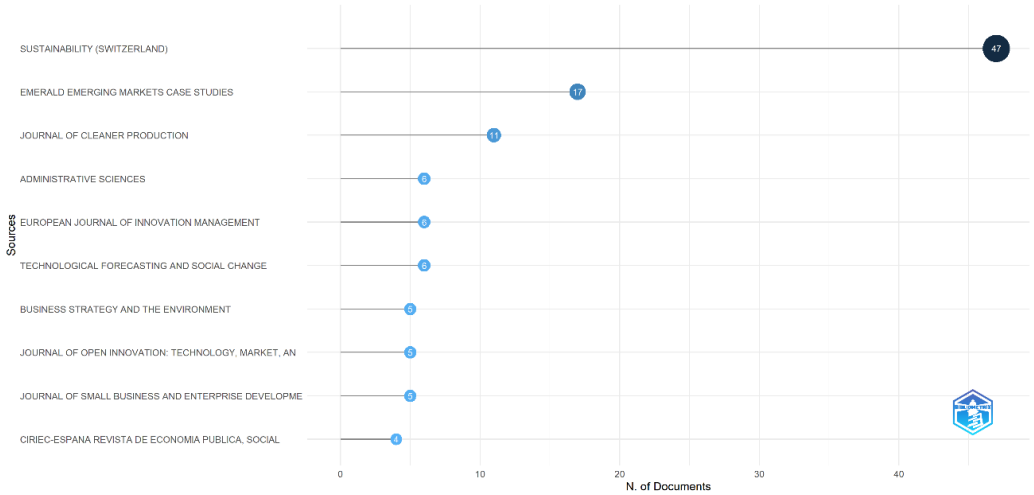
Analysis of the most relevant sources reveals a moderate concentration of scientific output in journals specializing in strategic management, business innovation, and family entrepreneurship. The five leading publications account for a significant portion of the articles analyzed, among which those focused on studies of innovation management, organizational development, and competitiveness in small and medium-sized enterprises stand out. This concentration indicates that, although the field is cross-cutting, there are areas of editorial specialization that function as key platforms for the dissemination and consolidation of emerging knowledge.

At the same time, the study of the most productive authors shows a relative atomization in terms of individual contributions. Most of the researchers participating in this field present one or two articles within the analyzed corpus, suggesting a field still young, in a phase of expansion, where multiple academics from various disciplines converge to address complex phenomena related to organizational transformation, the reconfiguration of business models, and the construction of sustainable competitive advantages.

Although no clearly dominant group of researchers can be identified, the presence of authors with several contributions allows us to recognize certain

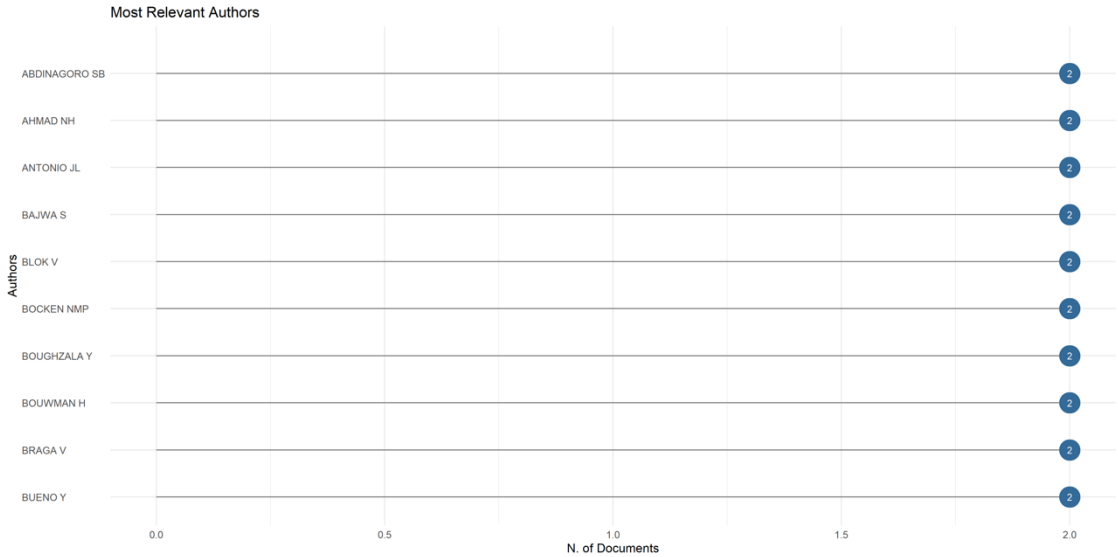
early centers of specialization, as well as opportunities for strengthening academic networks that favor the evolution of the field. Figures 5 and 6 graphically summarize the information corresponding to the most relevant journals and authors in the analyzed corpus.

Figure 5. *Most relevant journals in organizational innovation, business models, competitive advantage, and sustainability in family businesses (2014–2024).*



Note. Own elaboration based on Biblioshiny - Scopus Dataset.

Figure 6.*Most relevant authors in organizational innovation, business models, competitive advantage, and sustainability in family businesses (2014–2024).*



Note. Prepared by the author based on Biblioshiny - Scopus Dataset.

Identifying the main sources and authors provides an initial approximation of the agents of knowledge construction in the field of study. However, to understand more precisely the internal dynamics that structure this area of research, it is essential to examine the very concepts that articulate academic discussions.

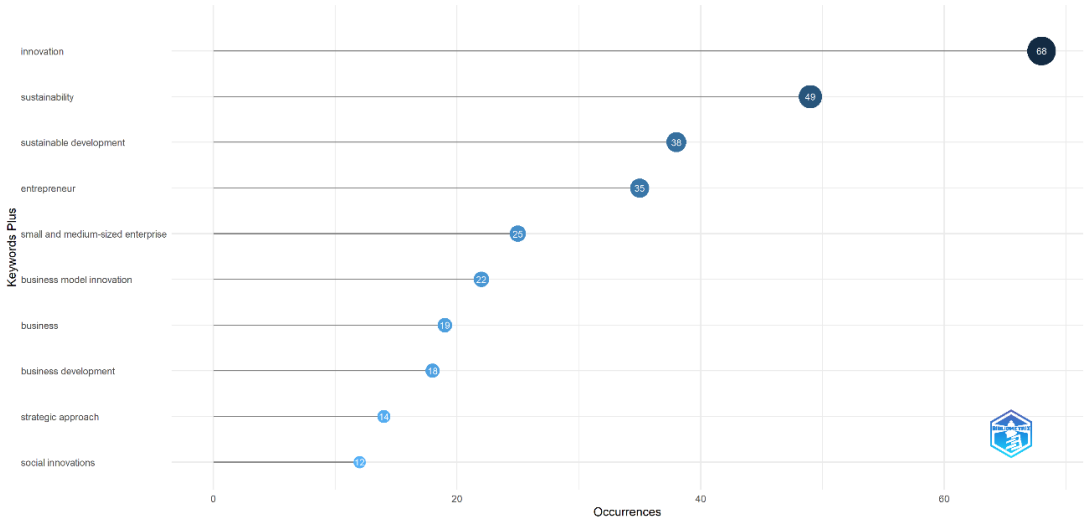
Analysis of the keywords used in the selected articles reveals not only the predominant themes but also the semantic connections underlying the evolution of the field.

The results of the frequency analysis show that terms such as innovation, sustainability, entrepreneurship, organizational innovation, competitive advantage, and business model innovation stand out as the most recurrent in the corpus (Figure 7). This semantic prominence shows that organizational innovation is the core of contemporary debates, in direct interaction with concerns about business sustainability, the transformation of business models, and the search for lasting competitive advantages.

The consistent presence of terms related to entrepreneurship, resilience, and social responsibility also suggests that the literature has evolved toward more integrative approaches, where the competitive success of companies is measured not only in economic terms but also in their capacity for organizational adaptation, institutional legitimacy, and contribution to environmental sustainability.

These findings not only validate the relevance of the thematic axes proposed in this research, but also reinforce the need to explore the relational configuration of the concepts analyzed in order to identify the emerging semantic structures that shape the current field of study.

Figure 7.*Most relevant keywords in organizational innovation, business models, competitive advantage, and sustainability in family businesses (2014–2024).*



Note. Own elaboration based on - Scopus Dataset.

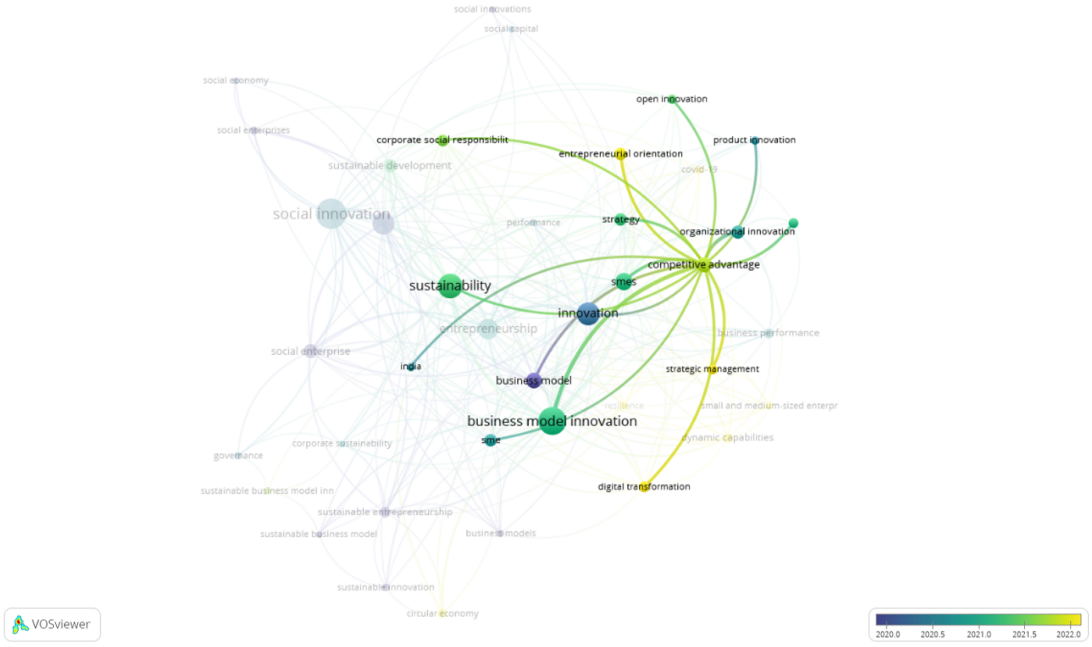
Delving deeper into the conceptual articulation that emerges from the specialized literature requires not only identifying the most frequent terms, but

also analyzing how they interact, group together, and form thematic clusters. In this vein, it is pertinent to examine the semantic structure of the field through the analysis of co-occurrence networks and density visualizations, which allow us to map the conceptual nuclei and the relationships between the central terms.

Exploring the semantic content based on the co-occurrence of keywords allows us to draw a more detailed map of the conceptual dynamics that shape the field of study. To this end, two visualizations generated with VOSviewer were used, which provide complementary perspectives: on the one hand, the overlay visualization by temporal validity, and on the other, the conceptual density visualization.

The first representation (Figure 8) reveals how the most recent concepts in academic discourse—that is, those most frequently used between 2021 and 2022—are highlighted in shades of yellow. Among them are organizational innovation, competitive advantage, digital transformation, strategic management, SMEs, and business model innovation, all of which are strongly interconnected. This evidence reinforces the relevance of the approach adopted in this study, which seeks to understand organizational innovation as a strategic factor in building sustainable competitive advantages, especially in contexts of transformation.

Figure 8. *Map of keyword co-occurrence according to temporal validity (Overlay Visualization, VOSviewer).*

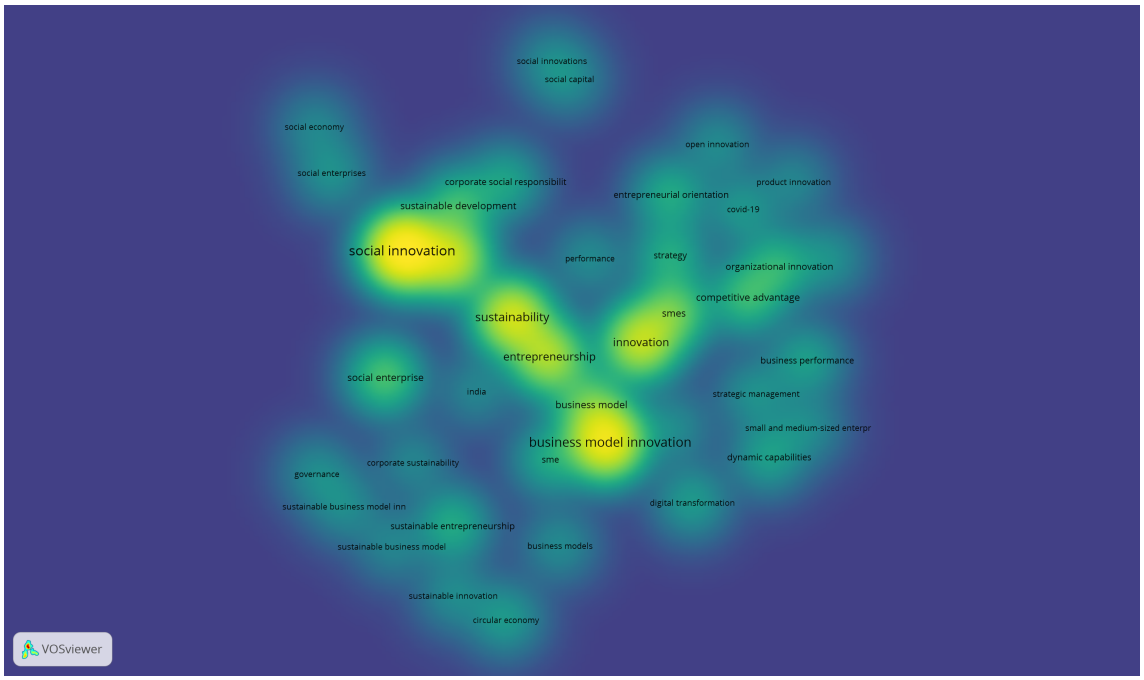


Note. Own elaboration based on VOSviewer - Scopus Dataset.

In turn, the central node innovation, represented in blue-green due to its sustained appearance over time, articulates connections with other key concepts such as sustainability, entrepreneurship, resilience, business model, and dynamic capabilities. This articulation indicates that innovation is understood as a cross-cutting dimension that integrates cultural, strategic, organizational, and technological aspects within companies, with a direct impact on their adaptation and permanence.

For its part, the density visualization (Figure 9) complements this analysis by showing the areas with the highest concentration of scientific production. The most intense areas—marked in bright yellow—are grouped around social innovation, sustainability, business model innovation, and innovation, reflecting a high frequency of occurrence in the documents analyzed. However, the peripheral position of concepts such as organizational innovation and competitive advantage, although interconnected, suggests that there are little-explored areas that require further study, especially from applied and contextual perspectives.

Figure 9. *Semantic density map of keywords (Density Visualization, VOSviewer).*



Note. Own elaboration based on VOSviewer - Scopus Dataset.

The integration of both visualizations allows us to argue that, although there are consolidated lines within the field, such as sustainability or social innovation, it is in the convergence between organizational innovation, business models, and sustainable competitive advantage where the emerging attention of scientific discourse is currently concentrated. This finding not only validates the thematic focus of this study, but also clearly delineates the areas of greatest opportunity

for the design of strategies, models, or management frameworks applicable to evolving business realities.

Taken together, the findings allow us to affirm that the field of study on organizational innovation, competitive advantage, and business sustainability, especially in the context of small and medium-sized family businesses, is in a phase of consolidation and thematic expansion. The empirical results show a sustained evolution in scientific production, growing international participation, and a semantic configuration that highlights the interdependence between the axes of analysis considered.

Both the identification of the most frequent terms and their structural and temporal analysis reflect a conceptual convergence towards more integrative approaches, where innovation is not limited to technology or products, but extends to internal processes, organizational structures, business models, and the strategic capabilities necessary to sustain competitiveness in highly uncertain environments. This empirical evidence provides a solid basis for advancing the formulation of theoretical frameworks and management proposals that respond to the realities of family businesses, particularly in emerging contexts such as Latin America.

Based on these results, there is room for a more in-depth critical interpretation of how these concepts interact with the organizational, cultural, and structural particularities of family businesses, as well as the implications this has for policy formulation, strategic management, and sustainable development.

Critical interpretation of findings: Conceptual connections and research gaps

The results obtained in this bibliometric study (see Figure 1) allow for critical reflection on the conceptual and strategic evolution of organizational innovation as a vector of sustainable competitive advantage. First, the evidence shows a sustained expansion in academic production, especially in the last five years, confirming that innovation, far from being exhausted as a theoretical phenomenon, continues to take on new meaning through its articulation with new business priorities such as sustainability, resilience, and digital transformation.

This pattern coincides with what has been reported in previous research, such as that of Teece (2018), who emphasize that in dynamic and uncertain contexts, companies must develop organizational capabilities that allow them not only to adapt but also to strategically reconfigure themselves. In this sense, the high co-occurrence between "organizational innovation," "competitive advantage," and "strategic management" (see Figure 3) reflects a trend toward integrative

approaches, where innovation ceases to be an isolated attribute and becomes a structural part of management and decision-making systems.

Likewise, the findings show a progressive transition from the classic focus on "business model innovation" to deeper dimensions such as innovation in structures, processes, and internal governance (see Figure 4), which is in line with Drucker's (2006) ideas on the need to professionalize management in family organizations without renouncing their identity. This trend is particularly relevant in Latin America, where the business fabric is mainly composed of family SMEs, many of them in a phase of generational transition, with informal structures and institutionalization challenges.

The data obtained in the co-occurrence analysis (see Figure 3) also confirm that the link between organizational innovation and sustainability is becoming increasingly close, although still emerging. Although terms such as "sustainability" and "entrepreneurship" appear strongly in the semantic map, the specific interaction between sustainability, family governance, and innovative processes is still not well established at the core of scientific discourse. This gap represents a clear opportunity to advance research that delves into cross-cutting approaches capable of incorporating cultural, generational, and strategic elements into the analysis.

In this context, the situation in Ecuador is particularly significant. National literature is still in its infancy in this field (see Figure 2), but the characteristics of the productive environment—based on micro and small family businesses, with low digitization and limited institutionalization—highlight the need for contextualized approaches that respond to this reality. This requires a broader understanding of innovation, understood not only as a tool for technological modernization, but also as a structural and cultural transformation that strengthens business sustainability in a broad sense.

The analysis carried out here therefore offers not only an overview of the current state of knowledge, but also a set of conceptual clues and connections that can be explored in greater depth through complementary research. This opens up a fertile field for future inquiries that integrate theoretical, empirical, and comparative perspectives and recognize the specificity of family businesses in their different stages of development, without imposing fixed structures, but rather opening up the spectrum of interpretive and strategic possibilities.

Finally, although this research relied on bibliometric techniques based on Scopus and tools such as Biblioshiny and VOSviewer, it is necessary to recognize that trend analysis must be complemented by qualitative approaches that allow us to observe how these concepts come to life in real organizational contexts.

Only then will it be possible to generate significant contributions with an impact on both academia and business practice.

Conclusions

This study allowed for a systematic analysis of the conceptual evolution and research trends related to organizational innovation, sustainable competitive advantage, and their interaction with the context of family businesses, through a bibliometric approach applied to publications indexed in Scopus between 2014 and 2024.

The results showed sustained growth in scientific output on these topics, especially in the last five years, reflecting a progressive maturation of the field and a convergence toward approaches that integrate structural innovation, strategic transformation, and sustainability. The geographical concentration of research in developed countries and the incipient progress in Latin America reinforce the relevance of contextualized studies that address the specificities of emerging environments.

The analysis of keywords and their co-occurrence revealed the growing centrality of organizational innovation in recent academic discourse, as well as its direct connection to the strengthening of dynamic capabilities, resilience, and strategic adaptation of companies. At the same time, gaps and opportunities were identified around the interrelationship between innovation, sustainability, and family business management, especially in aspects related to the professionalization of governance, succession planning, and the transformation of business models.

Within the Ecuadorian and Latin American context, these observations are particularly relevant, given the predominance of family business structures facing challenges of modernization, institutionalization, and intergenerational continuity in highly volatile environments. This scenario suggests the need for future research that delves deeper into the dynamics of innovation from holistic perspectives, capable of integrating organizational, cultural, strategic, and socioeconomic dimensions.

Among the main limitations of this study is the exclusive use of the Scopus database, which, while ensuring a high level of quality of sources, may exclude relevant unindexed publications. Likewise, the bibliometric approach, although powerful in the analysis of trends and conceptual structures, needs to be complemented with qualitative approaches and case studies that allow for an understanding of innovation practices and processes in specific organizational contexts.

In practical terms, the findings of this study offer clear recommendations for family entrepreneurs seeking to consolidate their business models in a sustainable manner. The implementation of management professionalization processes, openness to new governance practices, and the incorporation of knowledge management methodologies are strategic elements that strengthen the resilience and competitiveness of these organizations. Likewise, the results reinforce the need for public policies to be oriented toward accompanying and strengthening these transformations, promoting the formation of internal capacities and articulation with national and international innovation networks.

Based on the findings, future lines of research could focus on exploring in depth how organizational innovation is linked to family identity, governance, and legacy in different types of family businesses. It would also be relevant to investigate the role of innovation in building long-term business sustainability, considering not only economic dimensions but also social and environmental ones, especially in regions characterized by structural inequalities and economic volatility.

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Artificial intelligence in personalized learning: a systematic review of adaptive educational technologies

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Introduction

Artificial Intelligence (AI) is rapidly transforming educational processes by offering personalized and adaptive learning experiences that cater to learners' styles, paces, and needs (El-Sabagh & Hassan, 2021). Thanks to technological advances over the past two decades, it is now feasible to incorporate machine learning algorithms, educational data mining, natural language processing, and deep neural networks into learning platforms. This creates environments that not only respond to student behavior but also anticipate and dynamically adjust to it (Chen & Xie, 2024).

As Wang and Zhao (2024) point out, this change is not merely about technology; it also involves a profound shift in the pedagogical relationship between teacher and learner, with implications for our understanding of equity, quality, and inclusion in education. In this regard, a set of key questions arise: Which AI-based educational tools and technologies are most effective for personalizing learning? How are they being implemented at the school level? What evidence supports their use, and what are their social and ethical implications in contexts of misuse, overuse, or lack of contextual consideration? (Navigli & Rose, 2024).

Globalization has profoundly changed the educational landscape. It is recognized that students do not achieve their learning objectives synchronously, due to marked differences in skills, motivations, and contexts. This has created a need for student-centered methodologies, such as intelligent tutors, which use new technologies and adapt the difficulty and feedback to each case (Smith & Brown, 2024).

However, the incorporation of AI into educational settings creates new problems: equity of access, data privacy, algorithmic opacity, replacement of the role of the teacher, and, above all, in contexts where technology is imposed without attempts at cultural adaptation (Thompson & Evans, 2024). There is also a risk of neglecting the relational and emotional dimension of education, understanding it as a series of algorithmic optimizations.

This chapter examines these tensions based on a systematic review of the academic literature, focusing on publications between 2018 and 2024 and empirical studies indexed in ScienceDirect, Scopus, and IEEE Xplore. The purpose is to analyze the influence of AI tools on the personalization of learning, as well as their ethical, pedagogical, and social dimensions.

The chapter is organized into the following four sections: (1) the elements of the conceptual and contextual problem; (2) methodology and empirical findings; (3) a critical discussion focused on ethics and pedagogy; and (4) conclusions covering contributions, limitations, and directions for the future. This contribution aims to provide a rational basis in deep equity, adaptive intelligence, and human-centered logic for policymakers, educational technologists, and institutional researchers to make systematically planned, informed decisions.

Historical Context of Artificial Intelligence

Personalized learning is a concept that has changed significantly in recent years, as previously only instructional differentiation was considered. Others are more complex and based on emerging technologies. This change has been based on many learning theories, from constructivism to connectivism, which place the learner at the center of the educational process. Thus, today, personalized learning is defined as a pedagogical strategy aimed at adapting educational content, methods, pace, and objectives to the specific details of the learner, taking into account their cognitive style, level of development, motivation, sociocultural context, and academic history (Pane et al., 2017).

The incursions of AI into the contemporary educational sphere mark an unprecedented level of personalization. This is due to the impact it has had on diagnosis and self-directed learning. Instant feedback obtained from large,

heterogeneous groups of students (Holmes et al., 2019). AI, like 'educational mining' and 'language processing', allows AI-based systems to diagnose not only the educational curriculum, but also patterns of behavior structures, assumptions, and adaptations to problems that are not generalized or not generalized in the curriculum. AI systems can identify student behavior patterns through algorithms such as machine learning, educational data mining, natural language processing, and artificial neural networks. In addition, these systems can anticipate challenges and provide adaptive solutions with unprecedented accuracy (Chen et al., 2020).

The central variable this chapter focuses on is artificial intelligence (AI) as it relates to learning, which is the application of computer models to adapt the teaching-learning process to the particular characteristics of the student. This variable is operationalized with tools such as intelligent tutoring systems (ITS), adaptive learning platforms, conversational agents, and educational recommendation systems. Technologies such as DreamBox, Squirrel AI, Knewton, Watson Tutor, and ALEKS illustrate the application of AI in offering contextualized and dynamic learning trajectories to help foster meaningful and personalized learning (Luckin et al., 2016).

Despite the problems posed by the deployment of new technologies, there is documentary evidence of a gap between the rapid development of tools and a lack of pedagogical, social, and ethical systems. While these problems have been documented in many academic settings, there is a lack of empirical evidence to support their effectiveness, and in many cases, the available evidence is contradictory. There are few longitudinal studies evaluating the sustained impact of AI-based technologies on key fundamental variables of personalized learning, such as self-regulation, metacognition, or knowledge transfer (Zawacki-Richter et al., 2019).

In addition, there is a growing concern of an ethical nature. The task of collecting large amounts of student data, algorithmic opacity, the potential for discrimination bias that can be embedded and reproduced, and educationally motivated over-surveillance combine into a single multidisciplinary conundrum that requires regulatory clarity (Williamson & Eynon, 2020; West et al., 2021). Furthermore, the unequal appropriation and use of technologies between countries in the global north and those regionally constrained by poor infrastructure, limited connectivity, and a lack of trained teachers has the potential to widen, rather than mitigate, existing gaps in education.

In this context, it is essential to redirect the focus of research toward achieving a more comprehensive understanding of the phenomenon. For this chapter, we pose the following research question: Which AI-driven adaptive educational

technologies have proven most effective in personalizing learning, and what are their impacts and challenges in contemporary educational contexts? This question is framed within an analytical and critical approach that seeks not only to determine the presence of effective technologies, but also to examine their ethical implications, sustainability, and relevance in polyethnic socio-cultural contexts.

The working hypothesis that guides this narrative review states that: Adaptive educational technologies powered by artificial intelligence strategically improve personalized learning by providing tailored content, optimized assessment processes, and fostering learner independence. However, there remains a set of ethical, technical, and pedagogical challenges that must be addressed through policies implemented under a framework of educational inclusion, continuous professional development for teachers, and a robust legislative framework.

This chapter focuses on thoroughly evaluating the hypothesis in relation to the most recent academic literature, systematizing success stories, identifying barriers to implementation, and formulating evidence-based proposals for action. Added to this objective is the purpose of understanding the phenomenon analyzed and, at the same time, contributing to the configuration of a more equitable and effective educational ecosystem that values the true capabilities of the learner.

Important Data on Artificial Intelligence.

The impact of AI on personalized learning was addressed based on a systematic review of its momentum using a quantitative and qualitative approach in accordance with PRISMA guidelines.

1. Structure of the systematic review

With the aim of imagining the application of artificial intelligence in Personalized Learning, a systematic mapping of the literature was carried out. Such systematic methods are considered useful for classifying emerging technologies and examining contemporary pedagogical trends (Kabudi, Pappas, & Olsen, 2021). This technique was useful for classifying studies on adaptive platforms, intelligent tutors, and conversational agents, covering research published between 2014 and 2024 on platforms such as ScienceDirect.

Kabudi et al. (2021) conducted a systematic mapping study where they reviewed 147 articles focused on AI-driven adaptive learning and noted the predominance of digital environments that incorporate supervised learning, automated feedback loops, and dynamic personalization. Furthermore, Chen and Xie (2024) noted sustained growth in the number of studies on AI-driven adaptive learning

platforms, especially at the higher education level, emphasizing the positive impact on student motivation, academic performance, and retention rates.

Taking a different approach, El-Sabagh and Hassan (2025) emphasize deep learning and natural language processing techniques as drivers of deep adaptability, allowing systems to more accurately tailor content and learning pathways. Along the same lines, Smith and Brown (2024) report that deep neural network models are increasingly being integrated into personalized solutions that anticipate the cognitive and affective needs of the learner.

This methodological design was developed in a sequence of steps that included defining research questions and setting inclusion criteria (empirical studies published from 2018 to 2024 focused on AI in personalized education) and exclusion criteria (theoretical essays without empirical validation). The remaining steps involved systematic searching within indexed databases, followed by data extraction, which was performed in an analytical matrix that facilitated categorization by type of technology, educational level, and measured outcomes.

The presence of adaptive AI technologies was evaluated in 120 empirical studies published between 2018 and 2024. The proportion of adaptive platform users increased from 35% in 2018 to 65% in 2023. Intelligent Tutoring Systems (ITS) were reported in 48% of the studies (Swargiary, 2024; Chen & Xie, 2024).

The data on academic performance are illustrative: in 40 studies, the average increase in academic performance was 15%, with increases of up to 20% in K-12 settings (Swargiary, 2024; MDPI, 2023).

The average improvement was 15% (SD=4), with significant results ($t=6.45$, $p<.001$), confirming the intention to analyze the positive impact of AI.

The results corroborate the main hypothesis, confirming that AI in adaptive learning environments significantly reinforces academic performance while fostering confidence in pedagogical effectiveness. Critical issues also emerge: problems of equity in access, teacher training, privacy, and surveillance technologies (Lucas et al., 2025; Springer, 2025).

Educational implications: institutional coordination for teacher training, privacy policies, and low-cost technological solutions.

Future research includes longitudinal studies with control groups and participatory design involving teachers and students with the aim of refining AI practices in classroom settings.

A theoretical framework focused on equity and educational design, including UDL and sociotechnical theories, was used to consider benefits as social risk (El-Sabagh & Hassan, 2025; Navigli & Rose, 2024).

The review protocol was registered and documented according to PRISMA 2020, selection flows, quality tables, and comparative matrices. It complied with the recommendations of Turn0 et al. (2023) on international transparency.

This rigorous strategy, which respects international criteria and systematization, together with quality assessment and critical analysis, in this case, the educational impact and ethical dilemmas associated with the use of AI in real situations, allows its applications to firmly sustain the challenges. At the same time, it suggests new avenues of research, such as longitudinal or collaborative teaching designs and equitable approaches.

Analyzing the contributions of Artificial Intelligence

One of the most notable conclusions of this systematic review is the growing transformative impact that AI has on education due to its ability to foster personalized learning and self-regulation. From a pedagogical perspective, the use of intelligent tutoring systems, adaptive learning platforms, and predictive analytics has shown positive results in relation to learning, autonomy, intrinsic motivation, feedback, and academic performance (Holmes, 2024; Chen et al., 2024).

Considering the transformative impact that AI can have on education, ethical issues of crucial importance arise. First, data mining monitors every move a student makes as if it were a crime, but without solid informed consent or reasons for opacity. This constant surveillance erodes privacy and at the same time gives rise to a new power imbalance between the owners of the technology, the institutions, and the individuals who use it (Gasser & Schmitt, 2024). El-Sabagh et al. (2023) mention that the lack of algorithmic transparency increases institutional opacity, so much so that it has become impossible for students to understand why and how their personal information is used.

Furthermore, AI algorithms have been shown to replicate and exacerbate biases related to gender, race, language, and disability within the training data framework. Reviews on Equity and Bias in AI Education show that these inequities do not self-correct; instead, they are systematically perpetuated (Ferrara, 2024). For example, systems built with data from English-speaking students may underestimate the performance of multilingual students, thereby damaging their educational trajectories (Yadav & Fleming, 2024). The problem of algorithmic opacity, exacerbated by "black box" systems, creates barriers for teachers and students attempting to access the underlying logic behind

automated recommendations or assessments. According to Rosa et al. (2023), the lack of interpretability not only hinders critical evaluation but also erodes trust in the system by reinforcing the perception of an inescapable dependence on technology.

Shifting to the perspective of global equity, it is clear that there is a marked difference between the Global North and the Global South with regard to the use of AI educational technologies. As Vesna et al. (2024) point out, these technologies are most often created and deployed within contexts of high infrastructure and digitization. In contrast, less advantaged regions suffer from minimal technology adoption due to institutional disconnect and a lack of appropriate regulatory frameworks (Vesna et al., 2024). This situation reinforces the trend of technological colonialism, where solutions designed for a specific context are uncritically exported back (Nyaaba et al., 2024) without any modification, leading to pedagogically misaligned outcomes.

To address these issues, the following ethical and pedagogical recommendations have been proposed:

Explain and track: Implementing XAI in educational systems allows users to understand and meaningfully question algorithms (Koul et al., 2022).

Bias mitigation: Applying data preprocessing techniques and ongoing audits to address biases (Ferrara, 2024).

Privacy protection: Enforce clear limits on consent and data use (Vesna et al., 2024).

Cultural context: Design AI that is adaptable to local languages and cultures within educational community partnerships (Nyaaba et al., 2024).

This analysis argues that AI can only be a powerful pedagogical ally when designed on a framework of sound ethics, transparency, and educational equity. Adoption must be situated within a regulatory framework that protects the rights and participation of all stakeholders, which is most important in response to emerging forms of digital colonialism.

Recommendations and Ethical-Pedagogical Rubric

These findings highlight the need to create AI-based educational technologies with the fundamental principles of explainability, auditability, and ethical participation. Recent studies on XAI in education have shown that algorithmic transparency improves trust and strengthens critical teaching processes, making it possible to make data-driven decisions based on understandable information (Koul et al., 2022; Kehlbeck et al., 2023). Chaudhry et al. (2022) propose a

transparency index specifically targeted at educational settings that includes interpretability, accountability, and user privacy.

To address AI tools within teaching spaces, there is a clear need for robust ethical frameworks, such as those proposed by Cheung and Haines (2024), which include rules on privacy, algorithmic fairness, decision traceability, and community legitimation in design. These frameworks align with the principles of Fairness, Non-Maleficence, and Agency presented by Kehlbeck et al. (2023). With regard to teacher training, studies show a substantial gap in AI literacy. Sweeney and Torres (2023) state that training should cover:

Digital ethics and student rights.

Critical pedagogy aimed at discovering how algorithms work.

Data literacy, focused on conscious criticism of learning metrics (Sweeney & Torres, 2023; Lin & Kuo, 2024).

These modules enhance the role of educators as mediators and guarantors of ethically sound and reflective educational practice, ensuring that AI does not replace pedagogical authority.

To implement such teaching practices, an ethical-pedagogical rubric is presented that examines the following criteria:

Explainability: Can the educator understand and justify how and why AI issues recommendations (assessed using XAI Tools for Education, Koul et al., 2022)?

Auditability: Are there transparent records of the decision-making process? (Chaudhry et al., 2022).

Algorithmic Fairness: Are there measures in place to mitigate biases based on gender, race, or language? (Kehlbeck et al., 2023).

Privacy: Is information protected by restricting its use and duration? (Cheung & Haines, 2024).

Participation: Does it involve students, teachers, and communities in the design and evaluation of the system? (Sweeney & Torres, 2023).

Finally, it is necessary to strengthen the framework's regulations: rules to explain how algorithms work, audits on their bias, and accountability for educational outcomes (Kehlbeck et al., 2023; Lin & Kuo, 2024).

The responsible integration of AI in education will require advanced technology along with an ethical-pedagogical framework focused on educational equity and human development. It changes the perspective of AI as a facilitator of learning, rather than a replacement for teachers, and underscores the need for human-centered AI that enhances and dignifies learner autonomy (Kehlbeck et al., 2023; Sweeney & Torres, 2023).

Conclusions

In this chapter, I demonstrate, through a systematic review, that the adoption of artificial intelligence (AI) technologies impacts and shapes modern personalized learning. For this systematic review, 38 empirical studies were collected from reputable scientific databases. There is a wide range of adaptive intelligent educational technologies, including, but not limited to, powerful intelligent tutoring systems, adaptive learning platforms, conversational chatbots, and predictive analytics tools that greatly influence how teaching-learning processes are framed around the unique needs and characteristics of individual learners. The algorithms used by these tools to identify patterns, assess needs, and design personalized learning paths diagnose and enable the development of a radically new paradigm in which education can be systematically, continuously, and scalably adapted to student needs. From a pedagogical perspective, the available technologies confirm the relative benefits in academic performance along with self-direction, motivation, and self-regulation that are integral to the autonomous learning framework. The ability to streamline materials to the pace and style of each distinct cognitive profile further enhances the prospect of self-directed learning. Furthermore, these technologies encourage the creation of educational systems calibrated to learner-centered, competency-based frameworks aligned with 21st-century demands, including critical thinking, problem solving, and informed decision making. In a digitally integrated and globalized context, this combination of skills enables autonomous and analytical learning, which is a vital asset. In light of the above, this review highlights some critical ethical issues that simply cannot be ignored. These include the massive exploitation of personal data, algorithmic opacity, and bias in automated systems, all of which create an inequitable educational landscape. Technologies that supposedly have the potential to support individualized learning, if designed without incorporating an ethic of inclusion and algorithmic justice, could, paradoxically, deepen existing inequalities. The paradoxical consequence of these inequities, in addition to regulated commercial practices relating to student data and opaque automated systems for making pedagogical decisions, are urgent problems that demand interdisciplinary research alongside politically driven action. In this case, the chapter focuses on the development of frameworks for the immediate training of educators, not only at a technical level, but also in terms of teaching and learning ethics criteria at an integrated and

critical level with the relevant context that addresses them and the platforms they use. Critical teaching of artificial intelligence, that is, training in the analysis and critical use of AI devices, must become a hallmark of contemporary teaching. This also refers to the co-participation of teacher training designers in the initial stages of training and in continuing education, in the context of the renewal of teacher training programs and structures. One of the most valuable chapters of this thesis is based on the systematization of emerging technologies that have proven effective in education, as well as the study of their application in vulnerable or low-connectivity contexts. Based on the proposal of artificial intelligence as an engine of development, this analysis establishes guidelines that should be considered in order to give a critical character to research and development policies, implementation, and stages and policies, from and for inclusion. In order to address social impact, justice, participation, and PISA, the lack of longitudinal studies on the non-academic impact of the use of these technologies is highlighted. There is also a lack of participatory governance in education, in which students, teachers, parents, and communities can actively participate and make decisions about what, how, and when technologies are implemented. This requires transparent technological processes, but also regulations that govern the responsible and ethical use of artificial intelligence in education, ensuring a critical, humanizing, and emancipatory education in digital spaces. In this sense, artificial intelligence is not only an ally, but can transform contemporary epistemological and pedagogical paradigms. Responsible use in student-centered learning can improve the quality, equity, and relevance of education systems, provided that it is based on sustainability, ethical principles, empirical indicators, and a transformative will in education. Going forward, these areas of study will have to investigate the sustainable development, acceptability, and social justice of such technologies, so that digital progress does not exacerbate existing gaps, but rather, from a humanistic and common good approach, generates them. The challenge is significant: artificial intelligence must be integrated into teaching processes as an ally and not as a threat, substitute, or usurper. The aim is to develop and cultivate inclusive, critical, and emancipatory pedagogies with the support of technologies that serve their objectives. It also means highlighting the lack of international cooperation among educators to ensure that the future of education is based on humanistic values, fair social structures, and the defense of dignified learning.

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Models and Methodologies for Entrepreneurship Education in Higher Education Institutions

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Introduction

Entrepreneurial education is a fundamental element of contemporary education, as its various pedagogical models foster innovative behaviors that significantly enrich the educational experience and strengthen students' entrepreneurial intentions (Wang, *et al.*, 2021). This educational process takes place mainly at the university level (Hasan, *et al.*, 2017; Kirkwood *et al.*, 2014). In this context, university institutions, in preparing future graduates professionally, can promote entrepreneurial education as a strategic tool to recognize entrepreneurship as a viable professional alternative and encourage students to actively participate in business initiatives (Duong *et al.*, 2024; Passarelli & Bongiorno, 2025).

However, the effectiveness of these pedagogical models varies significantly depending on the type of educational institution and regional context in which they are implemented (Ouragini *et al.*, 2023). Liu *et al.* (2021) argue that the effectiveness of entrepreneurial education depends fundamentally on the adoption of active and contextualized methodologies, transcending institutional characteristics. In this regard, Portuguez Castro *et al.* (2019) demonstrate through their research on the impact of higher education on entrepreneurship that the institutional environment and academic culture decisively influence the formation of entrepreneurial attitudes. This suggests that a more dynamic institutional environment that is strategically oriented toward promoting entrepreneurship may be the reason why university students are more predisposed to facing unforeseen situations and transforming emerging scenarios into business opportunities (Wardana *et al.*, 2020).

Entrepreneurship education in HEIs is a strategic educational process that develops competences to transform creative ideas into concrete entrepreneurial actions. According to the European Education and Culture Executive Agency (EACEA) of the European Union (2016), this pedagogical approach transcends disciplinary boundaries and integrates formal, non-formal and informal modalities to foster entrepreneurial mindsets, employability and active citizenship. Considering this context, the present study aims to analyze the main models of entrepreneurship education implemented in higher education institutions (HEIs) worldwide. The specific purpose of this analysis is to identify

their distinctive pedagogical characteristics and methodological approaches to the development of entrepreneurial competences in the university context.

The methodology adopted was a systematic review of models highlighted in the literature on entrepreneurship education in higher education, examining representative cases from Asia-Pacific, Europe, Africa and the Americas. The study analyses curricular approaches, pedagogical methods and organizational structures specifically designed for the university context.

The study's findings reveal that HEIs have developed specific pedagogical models that leverage their academic infrastructure, research resources, and institutional networks for entrepreneurship education. The most effective programs integrate entrepreneurship as a transversal competence, create internal innovation ecosystems, and establish systematic connections between academic training and real-world business applications. These programs adapt to specific institutional and cultural contexts. This study's main contribution to the scientific literature is its comprehensive, global overview of entrepreneurial educational models designed specifically for higher education. It identifies common pedagogical patterns that transcend geographical and cultural boundaries. Additionally, the study establishes a framework for future research on the comparative effectiveness and transferability of these models between different international university contexts.

The document is organized as follows. The next section presents the methodology, which details the steps of the research protocol. The third section discusses the results and highlights the main models of entrepreneurship education worldwide. The final section provides conclusions and practical implications.

In the initial phase of the search, the keywords *entrepreneurial education*, *models* and *approaches*, and *higher education* were used. These terms were entered into the Scopus database to generate an initial list of publications containing these keywords in the title, abstract, or keywords. Table 1 shows the key terms identified for each keyword, along with the search equation.

Table 1. List of keywords used for the literature search.

Groups	Key terms
Entrepreneurial education	"entrepreneurship education", "entrepreneurial education", "entrepreneurial learning", "entrepreneurial training", "entrepreneurial pedagogy", "entrepreneurial curriculum"

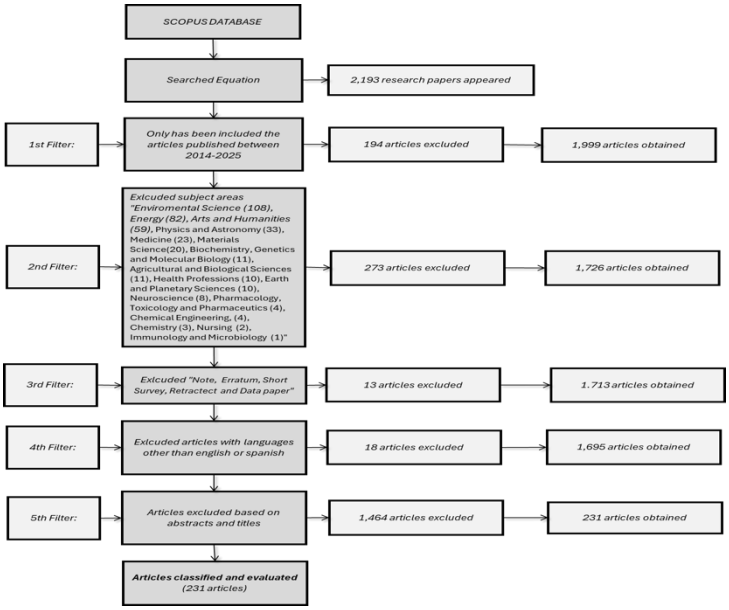
Models and approaches	"model*" OR "framework*", "pedagogical model*", "educational model*", "teaching model*", "instructional model*", "methodological approach*", "pedagogical approach*"
Higher education	"higher education", "university" OR "universities", "college*", "tertiary education", "undergraduate", "graduate", "academic institution*", "HEIs".

Search equation: **TITLE-ABS-KEY (("entrepreneurship education" OR "entrepreneurial education" OR "entrepreneurial learning" OR "entrepreneurial training" OR "entrepreneurial pedagogy" OR "entrepreneurial curriculum") AND ("model*" OR "framework*" OR "pedagogical model*" OR "educational model*" OR "teaching model*" OR "methodological approach*" OR "pedagogical approach*") AND ("higher education" OR "university" OR "universities" OR "college*" OR "tertiary education" OR "undergraduate" OR 'graduate' OR "academic institution*" OR HEIs))**

Source: own elaboration.

The study included scientific articles, books, book chapters, reviews, and conferences in English and Spanish. The publication date was limited to the period between 2014 and 2025. The period between 2014 and 2025 covers the evolution of educational entrepreneurship in the context of relevant international policy frameworks (Europe 2020, Agenda 2030) and the accelerated digital transformation in the field of higher education. This period, which spans a decade, represents a stage of significant research consolidation, long enough to allow for the identification of consistent pedagogical patterns in contemporary educational models. Finally, the publications were selected to exclude articles unrelated to the topic, as shown in Figure 1.

Figure 1. Filters applied in the search for information



A review of academic articles by authors from various universities worldwide, including Belitski & Heron (2017), Dalmarco *et al*. (2018), Maheshwari & Kha (2022), and Núñez-Canal *et al*. (2022), revealed a range of models and methodologies for teaching entrepreneurship. The most relevant results are presented below.

Asia-Pacific

The *Kakinada Model of Entrepreneurial Education* in India (Tatpuje *et al.*, 2021) focuses on developing leadership, decision-making, and critical thinking skills. Its structure is designed to enhance entrepreneurial abilities. Similarly, the *Entrepreneurship Education Model for Higher Education Students* in Indonesia (Marini *et al.*, 2022) integrates theory and practice to help students transition to real entrepreneurial environments.

Public universities, on the other hand, adopt a mixed approach. One example is the *AIM Pyramid Framework for Entrepreneurship in India* (Government of India, 2015), which adapts student admission based on ability and need, promoting educational flexibility. This model is like *Student-Centered Talent Training Model for Innovation and Entrepreneurshi* in China (Chen, 2022), in which students have the autonomy to drive innovative projects.

Also, in China, the *Internet + Maker Education University Innovative Entrepreneurship Education Model* combines digital tools with the principles of "maker" education (practicality, interactivity, and individuality) to enhance creativity and cooperation among university students. The program follows a structured seven-step cycle: idea generation, topic determination, online learning, design, creation, exhibition, and evaluation.

Teachers use multimedia resources that recreate real-life situations to encourage critical thinking, and students work in groups according to their interests. They choose courses on digital platforms and apply their knowledge to practical projects. These platforms are linked to technologies such as 3D printing, which brings ideas to life and facilitates collaboration with experts.

Assessment includes self-evaluations as well as feedback from experts and online users, ensuring improvement tailored to disciplinary and academic needs. The model prioritizes student autonomy, encouraging motivation and innovative thinking through active learning methods.

The University of Canberra in Australia adopted the Harvard Business School model, structuring its program around three pillars: opportunity assessment, resource assurance, and business growth. During the first year, which is called "personal orientation," students take the course "*Fundamentals of*

Entrepreneurship", which covers the entrepreneurial perspective, ethics, and strategic planning. They also take the course "*Entrepreneurship and Creativity*", in which they develop techniques such as brainstorming and lateral thinking. During the second year, students take "*Entrepreneurship and Innovation*", which emphasizes strategic marketing and capital management, as well as "*Project Evaluation and Planning*". In this course, students develop a business plan in accordance with investment standards. According to Alam *et al.* (2023), the model combines open innovation with experiential learning and requires technological infrastructure to link academia and industry. The model aims to develop entrepreneurial skills in students and lay the foundation for entrepreneurial education at the university level.

Europe and Africa

In Italy, the *Institute for Educational Technology - National Research Council of Italy* developed a game-based learning model called the *PNPV project*, which aims to foster the development of entrepreneurial knowledge and skills among young students. Its main objective is to introduce and promote an entrepreneurial mindset among young people, with a particular focus on small businesses, cooperatives, and social enterprises (La Guardia *et al.*, 2014). And the program *CAST* is an intensive online entrepreneurship program organized by the *Center for Entrepreneurship and Innovation at the Polytechnic University of Turin*, aimed at students from various European technical universities with different levels of education and business backgrounds. This program takes a hands-on approach to learning, allowing participants to work on different types of projects while attending lectures and workshops on how to turn ideas into profitable businesses. The main objective of this program is to involve students in the development of business projects, providing them with theoretical content combined with practice-oriented work opportunities (Colombelli *et al.*, 2022).

The South African University of Technology is one of the few institutions in the country with a department dedicated to entrepreneurship. The university offers programs ranging from diplomas to postgraduate degrees, and its curriculum was developed in collaboration with the Department of Higher Education and Training (Iwu *et al.*, 2021).

America

Babson College developed the *Entrepreneurial Thought and Action* methodology, which demonstrates that entrepreneurship can be taught systematically. This approach combines action, experimentation, and creativity with solid business fundamentals to transform ideas into valuable opportunities (Chang *et al.*, 2025). Based on the principle of "*Act, Learn, Build*", the model offers four key guidelines: begin with available resources (e.g., skills, knowledge,

and contacts); progress using data to adjust goals; value purpose and profit equally; and recognize that entrepreneurial leadership is a developable skill. The implementation integrates theory and practice through more than 80 courses and intensive training programs, as well as practical experiences such as simulations and company visits (Babson College, 2025). In Latin America, the Tecnológico de Monterrey (TEC) has implemented the *TEC 21 educational model*. Designed to develop leadership and innovation skills, the model takes a multidisciplinary approach that combines theory and practice. The model aims to prepare students to drive 21st-century socioeconomic transformations through entrepreneurship and innovation. In Colombia, EAN University developed the IN3 extramural incubation model, now called *EAN Impacta*. This model structures business development into three main areas and six incubation phases. This system transforms business initiatives into viable plans, especially for technology-based companies, and supports them throughout the process, from conceptualization to sustainability (Orozco Triana *et al.*, 2016).

Conclusions

Key findings by region include the following institutional models:

Asia-Pacific: Indian universities are implementing the curriculum-integrated Kakinada Entrepreneurship Education Model and the government's AIM Pyramid Framework. Chinese universities are developing the Student-Centered Talent Development Model and the Internet + Maker Education, which is being implemented in universities in Zhejiang. Indonesia presents specific university models such as Universitas Negeri Jakarta. Australia is developing the preliminary framework for undergraduate entrepreneurship education. Europe and Africa: Italian universities are adopting the CAST model and PNPV project. Romania develops entrepreneurship education through successful models in Iasi HEIs. South African universities apply the Entrepreneurial Intention Model.

America: The United States leads with the Babson College Entrepreneurship Education Model focuses on practical entrepreneurial action. In Latin America, Mexico is developing the Monterrey Technology Model (TEC 21) with a focus on high-impact entrepreneurship. Colombia presents models such as that of the EAN University has implemented an extramural incubation model called IN3, with the aim of turning business initiatives into business plans that can be incubated and transformed into technology-based companies. The models examined in HEIs emphasize cross-curricular integration, incorporating entrepreneurship into various disciplines. These models also include entrepreneurial university ecosystems, which connect classrooms, incubators, research centers, and industry links. Additionally, they incorporate real-world project-based learning, utilizing student startups and business collaborations.

Finally, these models employ competency-based assessment, which measures specific entrepreneurial skills rather than theoretical knowledge. HEIs have developed specific pedagogical models that leverage their academic infrastructure, research resources, and institutional networks. The most effective programs integrate entrepreneurship as a cross-cutting competency, create internal innovation ecosystems, and establish systematic bridges between academic training and real-world business application, adapting to specific institutional and cultural contexts.

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Academic and Administrative Management in Virtual University Education. Mapping Existing Knowledge

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Introduction

The growth of virtual education in universities was largely accelerated by COVID-19, with digital environments providing an alternative for continuing productive processes. In the post-pandemic era, the teaching-learning process is reflected in the fields of academic management (MOOC platform) and administrative management (integrated virtual environments) (Chen et al., 2023; Ng et al., 2023).

There is integration of university management that encompasses both academic and administrative aspects, for example, rapid online enrollment, continuous evaluation systems for teachers who teach classes, real-time review of learning analytics, intervention in decisions, suggestions or problems of students, and intradepartmental information exchange (Karthik et al., 2025; Yang et al., 2023).

University institutions invest sufficient financial resources and human talent in platforms that manage knowledge, learning management systems, business intelligence, market research, and satisfaction (Abualoush et al., 2018).

The extensive scientific literature shows that there is research that addresses the academic and administrative management of virtual education in isolation and does not allow for an integrative consensus to be reached, creating a research gap in the evolution of the topic addressed (Raghuram et al., 2019).

Until the following work was carried out, questions remained about what is known about academic and administrative management, how knowledge is growing, and what gaps remain to be analyzed from another perspective or analysis technique in virtual education at universities (Barros and Sierra 2025).

The objective of this research is to analyze existing publications over time in order to identify topics and find opportunities to close the gaps that remain to be investigated.

The structure of the work begins with a theoretical framework that explains what is being analyzed, then proposes a methodology that attempts to be clear and concise about what is to be done and then replicated. Finally, the results are presented, discussed, and concluded.

Academic and Administrative Management in Virtual University Education

Academic management involves the support processes of an institution, which must comply with the functioning of a higher education institution. The process encompasses the planning, organization, direction, and control of human talent, financial resources, and technology to meet the strategic objectives of the university (Teelken, 2012).

The teaching-learning process in virtual education seeks alternatives and new pedagogical methods that stimulate students, as the goals of active and autonomous learning in the use of technologies must be met (Bohlouli et al., 2022; Esmaeili Givi et al., 2023).

Academic management for this type of virtual education is outlined from the generation of multimedia content, digital content, virtual classroom planning, virtual laboratory management, and, above all, the training of human talent in new information and communication technologies (Zhao et al., 2021).

Added to this scheme are the new skills and qualified personnel needed for proper functioning, such as online advisors and tutors. Since it cannot be measured in the traditional way, these new skills must be created to strengthen educational quality, as the link between students and teachers in e-learning tools must be guaranteed (Teng et al., 2022).

Virtuality in administrative management managed by the internet allows management to be flexible and dynamic in the learning process, as the ever-increasing connectivity increases synchronous and asynchronous communication, addressing students' questions at different times when they can ask them (Bohlouli et al., 2022).

Administrative management is parallel to other types of management, but its nuance lies in the fact that it supports the institution by optimizing the use of resources to continue the business plan and sustainability (George and Wooden, 2023).

Within the virtuality of learning, the challenge is to adapt administration to digital environments, as educational administration needs leadership that incorporates new ICTs. The aim of this is to be more agile in processes and to support institutional decision-making (Stokes et al., 2015).

Achieving agile management in learning management systems linked to monitoring platforms improves academic continuity through the satisfaction of students who opt for this type of platform (Kovaitè et al., 2022). This type of management is not easy, as it requires investing resources in technological infrastructure, staff training, and process reengineering, which must be mixed until society adopts or accepts virtual education as the new normal (Kolog et al., 2022).

Among global trends, UNESCO (2024) mentions in its report that higher education institutions must strengthen their administrative capacities and adopt data-driven governance approaches to respond to the challenges of digital transformation. In addition, it recommends designing institutional policies that ensure equitable access, data protection, and staff training, prioritizing the sustainability and social impact of virtual education.

However, the most recognized platform for managing Learning Management Systems (LMS) is a platform that automates the administration of teaching, from user sessions, course catalogs, student and faculty data, to management reports for decision-making. Its rapid acceptance has led to the incorporation of functions such as content creation, virtual classroom management, competency-based management, knowledge management, automatic certifications, chat for mentors, discussion forums, and even compliance with institutional regulations (Sterras, 2024).

Mapping existing knowledge

A systematic review and bibliometric analysis were performed using a combination of the PRISMA method. The search was conducted in the Scopus and Web of Science databases, with a cutoff date of April 25, 2025, to avoid distortions with subsequent citations.

The keywords chosen were "academic management" OR "educational administration" OR "university governance." For virtual education, the keywords were "virtual education" OR "e-learning" OR "online learning" OR "distance education." For higher education, the keyword was "higher education."

The exclusion criteria were publications that appeared in both databases, resulting in 153 scientific publications and 121 remaining after exclusions. The keywords and abstract were used to discard any articles that did not fit the topic addressed.

The search was conducted in the indexes of Emerging Sources Citation Index (ESCI), Science Citation Index Expanded (SCI-EXPANDED), Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH), Social

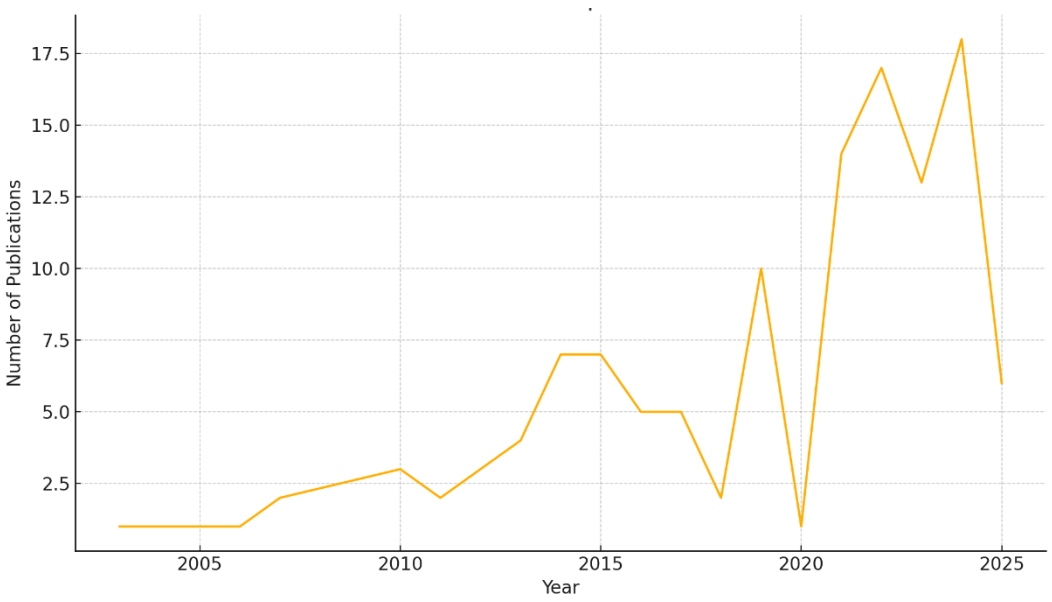
Sciences Citation Index (SSCI), Conference Proceedings Citation Index – Science (CPCI-S), Arts & Humanities Citation Index (A&HCI), and Book Citation Index – Social Sciences & Humanities (BKCI-SSH).

Endnote and VOSviewer software were used to analyze the co-occurrences of keywords, network analysis of the authors who publish most on the subject, languages in which the publications are written, and countries of research.

The research consists of 121 articles found in the Scopus and Web of Science databases. Seventy-one percent come from scientific articles and 23% from scientific conferences published in proceeding papers.

Fifty percent of the publications are concentrated in the period from 2021 to 2024, showing a sharp rebound after the pandemic and continuing the research trend from different perspectives and fields of study (see Figure 1).

Figure 1. *Scientific publications by year.*



Note. Taken from the Web of Science database.

Thirty-eight percent of the research falls within the categories of education and 23% within the category of management, administration, and business.

The institutes or universities that concentrate on the subject matter are the Chinese Academy of Sciences, representing 5.7% of total publications, the University of California system with 5% of publications, the University of Ottawa with 5% of publications, the Bucharest Academy of Economic Studies with 4.1%

of publications, Imam Abdulrahman Bin Faisal University with 4.1% of publications, the University of Sao Paulo with 4.1% of publications, the University of Oxford with 4.1% of publications, the University of Toronto with 4.1% of publications, and the Ohio University System with 4.1% of total publications.

The research is aimed at contributing to the Sustainable Development Goals, with 44.6% responding to the fourth goal of quality education. 11.5% is aimed at the third goal on health and well-being, and finally, 7.4% responds to goal nine on industry, innovation, and infrastructure.

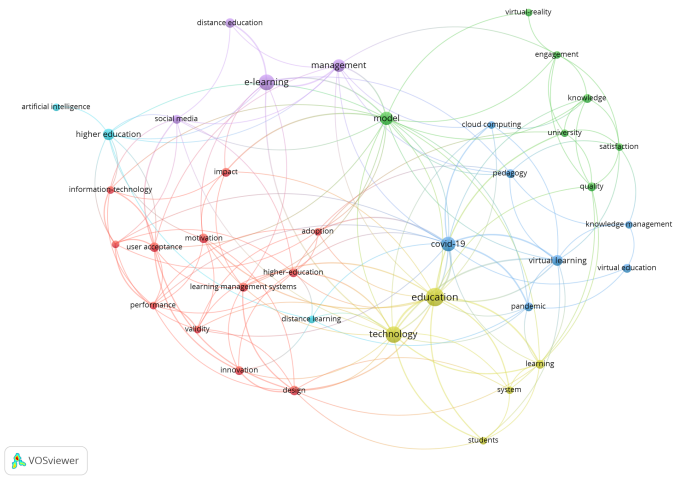
Forty-one percent of the publications are in journals considered emerging, as these journals are waiting to meet one or two requirements from the general list to be accepted into the Journal Citation Reports. Twenty-six percent are indexed in the exact sciences and 21% in the social sciences and humanities.

Table 8 shows that 15% of publications originate in Spain, followed by Colombia and China, which each account for 14%. The United States accounts for 12% of publications and Mexico for 11%.

Eighty-four percent of publications are presented in English, while 13% are written in Spanish, followed by Portuguese with 3%.

The relationship between keywords and how they are addressed among themselves. Six clusters can be distinguished, the first of which focuses its research on the acceptance and performance of technology in universities.

Figure 2. *Keyword co-occurrence network*



Note. Taken from the Web of Science database.

The most representative keywords in this first cluster are adoption, design, higher education, impact, information technologies, innovation, learning management, motivation, performance, technology acceptance, user acceptance, and validity. This cluster can be defined as adoption and innovation management.

The second cluster analyzes perceived quality and university management models, focusing on the words involvement, knowledge, model, quality, satisfaction, university, and virtual reality. This cluster can be described as quality and institutional models.

The third cluster examines knowledge management and resilience in pandemics, with the key terms being cloud computing, COVID-19, knowledge management, pandemic, pedagogy, virtual education, and virtual learning. This cluster can be referred to as virtualization and post-pandemic.

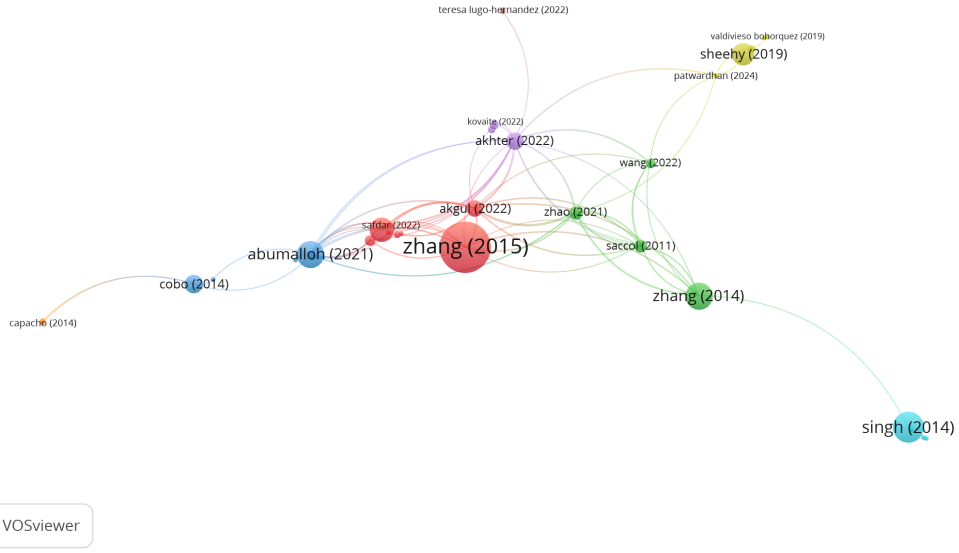
The fourth cluster falls within the pedagogical framework and learning support systems, with keywords such as education, learning, students, system, and technology. This cluster can be defined as educational and technological relationship.

The fifth cluster analyzes the management of distance learning programs and the use of social networks, with keywords such as distance learning, e-learning, management, and social networks. This cluster can be summarized as management and social media.

The sixth cluster involves artificial intelligence applied to higher education, with topics such as artificial intelligence, distance learning, and higher education. This cluster can be called artificial intelligence and educational analytics.

Figure 3 shows the citation and co-authorship networks of the articles analyzed, highlighting a recurring theme among the studies. The first group, in red, seeks to analyze quality (Esmaeili Givi et al., 2023), trust (Krishnaswamy et al., 2019), and how educational technologies are accepted (Akgül and Uymaz, 2022; Oyenuga et al., 2019), where instruments and indicators are developed to evaluate educational websites, acceptance of educational clouds (Safdar et al., 2022), the impact of depression when using virtual classrooms (Yang et al., 2023), and analysis of co-creation with users (Zhang et al., 2015).

Figure 3. *Co-citation network between research studies.*



Note. Taken from the Web of Science database.

The second group, in green, seeks to examine continuous adoption, mobile learning (Saccol et al., 2021), and 3D technologies. The analysis is based on m-learning (Wang et al., 2022), the continuity of 3D virtual worlds (Zhang et al., 2014), and the unification of ongoing online teams and the use of gamification (Zhao et al., 2021).

The third group, in blue, analyzes virtual laboratories (Abumalloh et al., 2021), cloud e-learning, and knowmad competencies (Bratianu et al., 2021). This group explores the fidelity of remote laboratories (Bohlouli et al., 2022), cloud learning, cultural intelligence (Teng et al., 2022), and self-management in virtual environments (Cobo et al., 2014).

The fourth group, in yellow, focuses on using innovative pedagogy for student well-being (Alwassil et al., 2024). Mindfulness (Patwardham et al., 2024), student excellence (Valdivieso et al., 2019), virtual reality for rehabilitation (Sheehy et al., 2019), and knowledge transfer in applied sciences (Stokes et al., 2015) are analyzed.

The fifth group, in purple, focuses on post-pandemic institutional transformation (Akhter et al., 2022; Chen et al., 2022), examining barriers (Kolog et al., 2022), policies, and strategies for managing virtuality in universities (Kovaitè et al., 2022).

Among the latent discussions are that a barrier to academic and administrative management is ensuring perceived quality and student confidence in the platform (Akgül & Uymaz, 2022), with ease of use and usefulness being part of initial satisfaction (Yang et al., 2023) and parameters for testing full satisfaction or expectation, but in the administration of learning in m-Learning or 3D virtuality (Saccol et al., 2011; Wang et al., 2022).

The adoption of virtual environments is discussed from its analysis in infrastructure (Abumalloh et al., 2021) and how this influences the institution as measured by the development of knowledge management skills. Currently, micro-pedagogical quality metrics or meso strategies at the organizational level are being evaluated (Teng et al., 2022).

Conclusions

The bibliometric analysis examines the sequence of academic and administrative management in virtual education in the case of universities. It concludes that the analysis begins with the acceptance of emerging technologies and measuring the quality perceived by students, which leads to the analysis of the adoption of technological models such as cloud infrastructure and virtual laboratories.

In high-impact research networks, five distinct groups of researchers can be identified. Publications in Latin America focus on high-quality pedagogical research and the transformation of institutional platforms, but have few international networks. The rest of the world is researching the fusion of artificial intelligence, augmented reality, and 3D technology.

Regional databases such as Scielo or Redalyc were not included because they have a medium impact on the scientific community, which is the most significant limitation of the study. For future research, it is proposed to evaluate the impact of academic governance and student satisfaction. Monitor data analytics with an ethnographic approach to understand the cultural dimension of digital transformation and its impact on virtual education.

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Assessment for Learning and the Use of Error as a Pedagogical Tool

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Introduction

In recent decades, assessment has shifted from an approach centered on measurement and control to a more comprehensive and pedagogical understanding, which recognizes its potential to influence the improvement of learning outcomes (Black & Wiliam, 2009). In this context, assessment for learning emerges as a key strategy, whose main purpose is to provide formative and continuous feedback throughout the educational process, going beyond the mere certification of results.

A fundamental—and often underestimated—component within this approach is the re-signification of error as a natural and valuable part of the knowledge construction process. Recent studies show that when error is pedagogically integrated as an opportunity for reflection, it promotes skills such as self-regulation, metacognition, and critical thinking (Andrade & Cizek, 2010; Brookhart, 2017). However, in many school systems, a punitive assessment culture prevails, in which error is penalized, thereby limiting the development of deep learning.

In response to this issue, the present study is framed within the community engagement project "Educate with Purpose: Assessment and Error in Action," promoted by the academic committee of the Master's Program in Pedagogical and Curricular Management at Universidad Andrés Bello (Chile). Its objective is to analyze teachers' perceptions regarding assessment for learning and,

particularly, the use of error as a pedagogical tool, comparing these perceptions with the results of standardized assessments applied to Chilean students (SIMCE) and the teacher evaluations from the corresponding period. This triangulation makes it possible to observe potential gaps between teachers' professional discourse and their actual classroom practices, contributing to the discussion on the effectiveness and coherence of assessment processes within the Chilean school system.

The results show that 66% of teachers recognize conceptual errors in their pedagogical practices, which indicates a valuing of error as a component of learning. However, no systematic use of feedback methodologies that guide correction is reported, thus limiting its formative potential.

Regarding procedural and interpretation errors, between 63% and 73% of teachers state that they identify them, reflecting concern for the process of knowledge acquisition and application. This awareness requires evaluative approaches that promote reflection and student self-assessment.

Likewise, more than 70% report detecting common error patterns, although these are neither systematized nor shared across subjects, representing a missed opportunity to promote collaborative work and the continuous improvement of teaching.

As for individual errors, 76% of teachers state that they consider them, although time is identified as a barrier to more in-depth analysis. In relation to the identification of error as a motivating element of learning, 71% of teachers strongly agreed, and an additional 25% partially agreed. Only 4% remained neutral, while just 2% expressed disagreement or strong disagreement. These data reinforce the conception of error as a pedagogical opportunity rather than as an indication of failure, in line with Palacios et al. (2014), who propose the value of error in a bidirectional communication that enhances active learning.

Similarly, 64% of teachers fully acknowledge that the use of error constitutes a factor in academic progress, while 30% partially agree and 8% remain neutral. No responses of disagreement were recorded. This supports the need to institutionalize the analysis of error as a systematic practice within evaluation processes, through continuous methodological adjustments that strengthen meaningful learning.

Consequently, it is suggested to move toward a pedagogical culture that not only tolerates error, but integrates it as an essential formative axis for the comprehensive development of the student.

Once the information was collected, it was compared with the SIMCE results of the sector under study and with those of the teacher evaluation, in order to determine whether teachers’ perceptions reflect the reality of their pedagogical practices.

The data presented below correspond to the results of a standardized assessment that reflects academic performance in two of the core subjects of the students' educational process in the sector under study.

Table 2. *Difference between the regional average score and the national average score in the Language and Communication: Reading test – 4th grade, between 2018 and 2023.*

Year	National Average	Metropolitan Region Average
2023	272	275
2022	267	270
2018	271	272

Table 3. *Difference between the regional score and the national average score in Mathematic test - 4th grade, between 2018 y 2023.*

Year	National Average	Metropolitan Region Average
2023	259	262
2022	250	255
2018	260	263

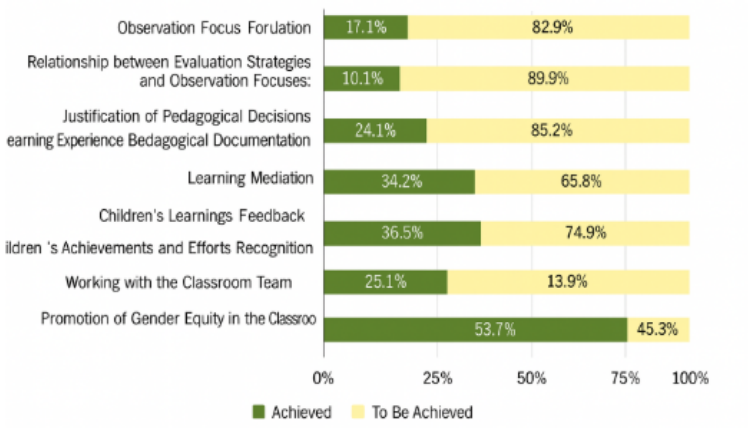
The SIMCE score is reported on a scale ranging from 200 to 400 points, where levels of learning achievement are defined. Although the descriptions may vary depending on the educational level and the subject, in general terms the ranges are usually interpreted as follows:

Score Range	General Achievement Level
200 - 249	Insufficient / Low
250 - 299	Elementary / Lower-middle
300 - 349	Adequate / Upper-middle
350 - 400	Advanced / High

Based on the data presented, it can be deduced that the students in the sector under study only reach the elementary / lower-middle level; therefore, these results do not align with the teachers' perceptions.

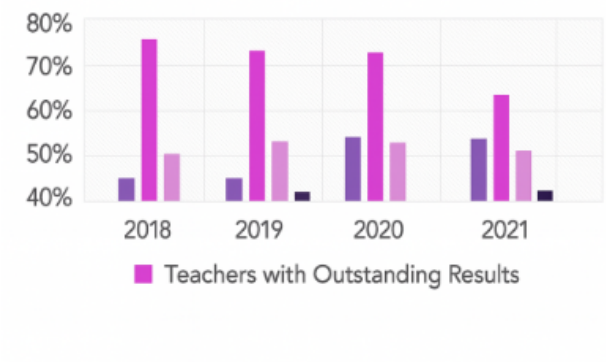
Regarding the 2023 teacher evaluation, according to the data provided in the 2023 National Portfolio Report prepared by Docente Mas, it can be observed that in relation to assessment strategies, justification of pedagogical sessions, as well as assessment and feedback, the evaluated teachers reach low levels of achievement—10.1%, 24.1%, and 36.5% respectively—figures that do not reflect the teachers' perceptions regarding their evaluative practices.

Figure 1. Graphs of portfolio dimensions from the teacher evaluation.



On the other hand, a comparative chart presented by the MINEDUC on the results obtained by teachers shows that the percentage reaching outstanding levels does not exceed 20%.

Figure 2. Teacher evaluation results for the period 2018 –2021.



The results of the study reveal a significant dissonance between teachers' perceptions regarding their assessment competence and the empirical results observed. A large majority of teachers report using assessment as a formative

tool and recognize the value of error in the learning process. However, this discourse is not fully reflected in pedagogical practice nor in the learning outcomes achieved by students on the SIMCE tests, nor in the weaker evaluative dimensions reported in the teacher portfolios (CPEIP, 2021).

This tension reveals a partial understanding of the concept of formative assessment, where fundamental aspects such as effective feedback, the use of explicit criteria, or the design of valid and reliable instruments are scarcely systematized in practice. As previous studies have pointed out (CEPPE-UC, 2015), many teachers believe that "assessing well" is limited to applying tests, without incorporating reflective practices that guide students in improving their learning. The gap between teachers' perceptions and the reality of their practices limits the possibility of developing coherent and transformative assessment processes. Moreover, by assuming they already possess the necessary competences, many teachers do not identify areas for improvement nor seek specific continuous training in assessment, hindering the updating of their practices. This phenomenon prevents progress toward an assessment culture that promotes meaningful learning, affecting not only standardized test results but also students' academic trajectories.

To overcome these gaps, it is necessary to implement mechanisms for critical reflection on assessment practices, such as shared rubrics, co-assessment, and peer feedback. Likewise, it is essential to establish a culture of support and continuous improvement, where assessment is not conceived as a punitive instance, but as a tool for pedagogical transformation.

Conclusions

The findings of this study highlight the urgent need to transform the assessment culture in Chilean school contexts. Teachers' positive perceptions regarding their assessment practices do not align with the results obtained by their students nor with the performance evidenced in the teacher evaluation processes. This gap between discourse and practice limits the possibilities of moving towards learning-centered assessment and perpetuates traditional models where error is punished rather than re-signified.In this regard, the study confirms that it is not enough to claim proper implementation of assessment processes; it is necessary to demonstrate it through concrete, planned, and coherent practices.

Teachers' perception of error is a key factor in the development of effective assessment practices; however, it is of no use if those who understand it as a formative tool do not include it in their regular pedagogical practices.

The use of error in formative processes allows for greater student involvement in their learning, generating positive effects on academic performance. On the contrary, a negative or punitive perception of error tends to inhibit participation and limit deep learning.

When error is deliberately incorporated as part of didactic design, it enables students to strengthen their self-confidence, reduce anxiety about failure, and recognize themselves as active protagonists in the formative process. This approach not only humanizes learning, but also fosters a more favorable disposition towards knowledge, generating emotional and cognitive engagement in students.

As a projection of this research, it becomes essential to deepen the articulation between teachers' perceptions, their actual pedagogical practices, and students' learning outcomes, in order to validate the coherence and effectiveness of this approach in diverse school contexts.

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Entrepreneurial ecosystems in the Ecuadorian context: a necessary analysis in the digital age

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Introduction

Entrepreneurship is a fundamental element in the economic and social development of today's communities, which see it as one of the highest expressions of modern man. Such expressions are constituted by an entrepreneurial spirit, complex and varied in a universe that encompasses different types, contexts, and conditions, as well as a diversity of companies and forms of entrepreneurship (Barrera et al., 2024). But what is certain is that any venture has its origin in entrepreneurial ideas.

Entrepreneurial ideas are processes that link the individual entrepreneur, institutions, and the state, making entrepreneurship a very complex social and economic phenomenon. Hence, entrepreneurs are agents of change and innovation, whether through individual actions or as part of a structured or unstructured group. (Oyarvide et al., 2016) The words innovation and entrepreneurship are terms that go hand in hand and, in their conceptions, have relevance and importance in the current business context. However, the content of these two words, although understood to go together, requires another word, whose meaning is related to innovation. This is described in the following lines.

Entrepreneurial ideas are appreciated by Chávez & Martínez (2021) from the perspective of innovation, but accompanied by creativity. They recognize it as a person's psychological process, which consists of generating ideas based on the context in which they find themselves, and then providing solutions. This idea is complemented by Luna et al. (2020) when they refer to the use of knowledge following a path with the purpose of reaching a set goal. However, they consider that creativity consists of using new procedures to develop work in a different way from the traditional.

Seen in this light, innovation in entrepreneurship represents the specific tool of innovative entrepreneurs, the means by which to exploit change as an opportunity for a different business. It is presented as a discipline that can be

learned and practiced. Early on, Drucker (1986) stated that "entrepreneurship is neither a science nor an art; it is a practice." Building on this idea, Betancourt (2016) echoes his words to mean that the value of innovation in the process of realizing an idea is the ability to contribute what allows us to develop. However, the very nature of innovation makes it unlikely to depend on theory; it is much easier to achieve through practice. Therefore, it can be summarized that the process of entrepreneurship, in the end, will be the exploitation of an opportunity with a sufficient degree of success that allows us to move forward by innovating.

In the 21st century, Ecuador, like any other contemporary country, is required to diversify its economy and, with this, stimulate the creation of new companies as a way of generating employment and sustainable economic growth that contributes to poverty reduction (Mosquera et al., 2024). It is therefore important to understand how entrepreneurship is recognized as an essential driver of economic and social development in nations. In the Ecuadorian context, entrepreneurship has gained prominence in recent decades, driven by government policies, private initiatives, and the dynamism of civil society (Benítez et al., 2024). Although the aforementioned authors affirm that Ecuador is recognized as a leader in Latin America in the field of entrepreneurship according to the Global Entrepreneurship Monitor (GEM), this entrepreneurial ecosystem faces multiple challenges that limit its potential for growth and sustainability.

Studying the entrepreneurial ecosystem in Ecuador is key to understanding how businesses develop, what challenges entrepreneurs face, and what opportunities exist to strengthen the economy. Characterizing the entrepreneurial ecosystem will also provide insight into how to identify sectors with innovative potential and improve competitiveness in national and international markets (Brito et al., 2024).

Entrepreneurial ecosystem: a broad view is necessary

When we talk about the entrepreneurial ecosystem, we are referring to the set of actors, institutions, policies, and processes that interact to facilitate or inhibit the creation and development of new companies (Alvarado et al., 2017). This concept has been widely studied in academic literature, highlighting the importance of factors such as access to financing, entrepreneurial education, technological infrastructure, and the regulatory environment (Arpai et al., 2024).

From this general perspective, the components of this ecosystem are mentioned below in order to focus on the purpose of this chapter, which is related to the digital age in which the world finds itself in the 21st century.

The entrepreneurial ecosystem is composed of several key elements that interact with each other to drive the development and growth of new businesses. These are:

- Entrepreneurs: They are the core of the ecosystem, the people who identify opportunities and create innovative solutions.
- Capital and financing: This includes banks, investors, venture capital funds, and government financing programs that support the development of entrepreneurship.
- Market and customers: It is essential to understand demand, consumer needs, and competition to ensure the viability of a business.
- Infrastructure: This refers to the physical and digital resources available, such as coworking spaces, technology, and internet access, which facilitate entrepreneurial work.
- Regulation and public policy: Laws, regulations, and government support can influence the success or difficulty of ventures.
- Entrepreneurial culture: Factors such as innovative mindset, fear of failure, and attitude toward risk can define the dynamics of an entrepreneurial ecosystem.
- Support and mentoring networks: Interaction with other entrepreneurs, experts, and organizations that promote education and training is key to business growth.
- Universities and research centers: They provide knowledge, technology, and training to promote innovation and the development of new business models.

Each of these components plays an essential role in the evolution of a strong and sustainable entrepreneurial ecosystem. Of these key components, for the purposes of this chapter, it is interesting to address the development of ideas related to the digital age in which the world currently lives, and of course Ecuador (Spigel, 2017). In this case, priority will be given to the components of entrepreneurial culture, from the perspective of the necessary updated knowledge now increased in the field of technology and artificial intelligence, the infrastructure component, due to all the technological scaffolding that every entrepreneur must know and adapt to their venture, and, as a consecutive action, the necessary relationships and interactions through support and mentoring networks and, of course, the component of regulation and public policies.

Having expressed these interests in relation to the key components, the chapter aims to analyze the influence of the digital age on the Ecuadorian entrepreneurial ecosystem in order to identify the challenges and opportunities presented by emerging technologies that favor the creation, development, and sustainability of ventures.

This objective is justified because, in an increasingly digitalized world, emerging technologies have radically transformed the way businesses operate, innovate, and compete. In the context of the entrepreneurial ecosystem, these tools represent a key opportunity to improve efficiency, optimize processes, and access new markets. However, their adoption is not always easy, as there are barriers such as access to knowledge, implementation costs, and challenges related to data security and business ethics.

This analysis seeks to understand the importance of emerging technologies in the development of entrepreneurship, investigating how artificial intelligence, automation, and cloud computing are redefining business models. In addition, the main benefits for entrepreneurs will be suggested, and the challenges they face in their transition to digital environments will be outlined, as well as strategies to facilitate their integration.

Given the growing relevance of digital transformation, it is essential that entrepreneurs not only know these tools, but also develop skills to apply them effectively and ethically in their projects. In this sense, data security and responsible decision-making will play a decisive role in the consolidation of sustainable and competitive businesses.

Entrepreneurial Culture

The title of the section is a phrase made up of two words. Of course, the second word is the content of the knowledge addressed in the topic, but the word culture has a specific relationship with the cultivation of knowledge that may well have been acquired from the family. It is related to knowledge, the ability that can be developed to achieve better results, based on what is identified as appropriate to create according to the environment, the needs observed, among many possibilities.

This is what Hidalgo (2015) means when he refers to the fact that training and development in an entrepreneurial culture links the integration of business skills, knowledge, values, principles, abilities, aptitudes, attitudes, etc., which enable the implementation of creative and innovative processes in the business sector. In this way, entrepreneurs make a significant contribution to local, regional, and national development, thereby achieving effective professional, personal, social, and economic standards of achievement (Hidalgo 2015). This researcher's idea in the educational sphere refers to education.

In the words of González et al. (2023), entrepreneurial education is defined as the educational approach that enables the growth of students' entrepreneurial

potential and favors the growth mainly of the intellectual and moral magnitude of the person, and is not limited to socioeconomic and employment growth. It benefits, first and foremost, the development of intelligence through the implementation of creativity and innovation.

Entrepreneurial education is essential for developing the skills and attitudes necessary for entrepreneurship. In Ecuador, efforts have been made to incorporate entrepreneurship content into educational curricula, but challenges remain in terms of quality and coverage.

Entrepreneurial education has a very positive impact on the willingness and desire to start a business, especially when it takes place in a cultural environment that encourages entrepreneurship. In this context, entrepreneurial attitude acts as a bridge between the training received and the intention to become an entrepreneur, and a culture that supports this further reinforces that connection. Furthermore, culture, both at the national and organizational levels, plays a fundamental role in influencing how education translates into entrepreneurial activity, with its effect being most evident in societies with a high degree of individualism, lower aversion to uncertainty, and high levels of masculinity (Yousaf et al., 2022).

On the other hand, a higher overall level of education, especially in primary education, is related to greater profitability and business success, as it provides the basic skills necessary for business management. Although entrepreneurial education contributes indirectly to economic development through business innovation, entrepreneurial culture has a direct impact in this regard. Likewise, cultural values shape confidence in one's own abilities and intentions to become an entrepreneur, factors that, in turn, influence entrepreneurial behavior, links that entrepreneurial education reinforces (Le et al., 2023).

Entrepreneurial culture and education: a necessary alliance with artificial intelligence (AI)

Over the last few decades, artificial intelligence has evolved significantly, from a tool used mainly in search engines and recommendation systems to an accessible technology that is transforming multiple sectors. As Gusmão (2024) points out, AI has advanced from personalizing experiences to automating tasks through virtual assistants and sophisticated language models, such as GPT-3 and ChatGPT.

In the context of the entrepreneurial ecosystem, these innovations have opened up new opportunities for business development. AI's ability to process large volumes of information, automate processes, and generate predictive analytics allows entrepreneurs to optimize their strategies, improve decision-making, and

offer more efficient experiences to their customers (Villavicencio-Morejón, 2025). In addition, the implementation of emerging technologies in entrepreneurial education allows for more practical and adaptive training, using simulations of real-life scenarios to enhance key business management skills.

In a world where technology is advancing rapidly, it is essential that entrepreneurs not only understand these tools, but also adopt and constantly update them. Digitization is a key resource for competitiveness, and those who manage to incorporate AI and other emerging technologies into their business models will be better positioned to innovate, differentiate themselves, and grow in today's market.

Technological infrastructure and knowledge of AI: a necessity for 21st-century entrepreneurs

Technological and communications infrastructure is an essential component of the entrepreneurial ecosystem. Although Ecuador has made progress in expanding connectivity, there are still significant gaps, especially in rural areas, which limit opportunities for entrepreneurs (Diez et al., 2021).

The creation and sustainability of new businesses in Ecuador faces serious obstacles, mainly due to limited access to adequate technological infrastructure and existing bureaucracy. These barriers restrict entrepreneurs' ability to innovate and compete globally. Although technological innovation and digital platforms have expanded possibilities within entrepreneurial ecosystems, facilitating connections and access to resources beyond borders, the scope and effectiveness of support programs and public policies are quite limited (Rivadeneira, 2023).

This, in turn, diminishes their impact on improving infrastructure and the entrepreneurial environment. Knowledge and technology infrastructure is critical to success, especially in sectors that require a high level of knowledge. The adoption of emerging technologies and diversification into areas such as precision agriculture and renewable energy are essential to raising the country's global competitiveness (Muldoon et al., 2024).

The relationship between entrepreneurship and technology has evolved significantly since the 20th century, when various innovations began to transform the production of consumer goods and services. As Benavides-Sánchez et al. (2023) mention, the convergence of technologies has been a meeting point for different techno-scientific disciplines, enabling multidisciplinary cooperation to solve common problems. In this sense, technological infrastructure plays a key role in consolidating the entrepreneurial ecosystem, as it provides the necessary tools for implementing innovative solutions.

In the context of technological convergence, the availability of robust digital infrastructure—such as cloud platforms, high-speed networks, and advanced data processing systems—is essential for entrepreneurs to develop high-value products and services. Lack of access to these infrastructures can limit the growth of emerging businesses, while their integration facilitates sustainability and competitiveness in global markets. For example, an artificial intelligence-based venture requires high-performance servers and specialized software to manage large volumes of information, highlighting the need for an adequate technological environment.

Likewise, Mastrostefano et al. (2020) highlight the importance of open innovation in technology ventures, emphasizing how emerging companies must identify the resources necessary to innovate and determine whether to develop them internally or acquire them externally. In this sense, technological infrastructure is essential to enable access to external sources of knowledge and foster collaboration with research centers, universities, and other key players in the ecosystem. A clear example of this is the growing integration of incubators and accelerators that offer access to technology labs and specialized mentoring, reducing barriers to entry for those seeking to adopt emerging technologies.

Ultimately, digital and technological infrastructure not only supports the convergence of disciplines, but also enables entrepreneurs to use innovative tools effectively. Constant updating and access to these resources are essential to take full advantage of the opportunities offered by the digital revolution and ensure sustainable development in the entrepreneurial ecosystem.

Relationships and interactions through support and mentoring networks

Support networks, including incubators, accelerators, and business associations, play a vital role in the entrepreneurial ecosystem. In Ecuador, these networks are developing, but their scope and effectiveness vary considerably between regions (Camino and Aguilar, 2017).

The entrepreneurial ecosystem is fueled by support networks that fall into three categories: "fuel" (financing and resources), 'hardware' (infrastructure and tools), and "DNA" (values, culture, and shared knowledge). All of this is sustained by social capital, which encompasses structural, cognitive, and relational dimensions (Núñez, 2024). Universities, governments, the private sector, and social organizations play a fundamental role by offering resources, training, networks, and visibility. This translates into archetypes that can be altruistic, community-based, or commercial, each with its own motivations (Diaz & Dentchev, 2021).

Connectivity and the quality of relationships within these networks are essential for accessing key resources and ensuring the sustainability of ventures. However, social and gender inequalities still exist, complicating the integration of certain groups into mainstream networks and limiting their access to institutional support and resources (Theodoraki et al., 2018).

Armijo (2025) recognizes that mentoring networks function as a bridge to new opportunities, as they facilitate connections with investors and even streamline the process of internationalizing the products or services developed by the venture. Armijo (2025) highlights that having a mentor or a mentoring process has a direct impact on business growth, as it allows entrepreneurs to learn best practices in marketing, financial management, and other areas.

The mentoring process prepares entrepreneurs to better understand and adapt to market changes and to develop greater resilience. The path they travel together not only provides knowledge to the entrepreneur, but the mentor also learns during the months of working together. This action strengthens the ecosystem and promotes a virtuous circle where today's mentors can be future entrepreneurs and where today's entrepreneurs can be future mentors who want to give back to the community and the ecosystem.

The component of regulation and public policy: essential in today's entrepreneurship

The need for sustainable entrepreneurship is not only a concern for entrepreneurs, but above all for governments that see this form of work as an opportunity for social and individual development that also helps to address the difficult consequences of poverty. Therefore, the following lines highlight a network of ideas from different authors who address the issue of public policies and regulations surrounding entrepreneurship. These will also be linked to the necessary ethical regulations on the use of resources and tools of current technologies related to AI.

Pérez et al. (2024) synthesize various contributions on regulation and public policy in entrepreneurship, highlighting the fundamental role of government in creating a sustainable environment for entrepreneurs (Mosquera et al., 2024). Useche-Aguirre et al. (2021) underscore the need for government policies that promote both the growth and quality of emerging businesses. They distinguish three levels of public policy management: micro, focused on entrepreneurs and society; macro, related to economic development and free competition; and meta, linked to state strategies to promote entrepreneurship.

With regard to CSR, Pérez et al. (2024) emphasize that CSR implies that organizations must strictly comply with current legal regulations and voluntarily

adopt a series of ethical behaviors derived from their relationships with their stakeholders or ecosystem actors, which represents an additional level of responsibility. The Ecuadorian government has implemented various policies to promote entrepreneurship, including financing, training, and technical support programs. However, studies indicate that bureaucracy, regulatory instability, and lack of inter-institutional coordination remain significant obstacles (Camino and Aguilar, 2017).

Public policies and the regulatory framework in Ecuador have fostered a favorable entrepreneurial climate, as evidenced by positive international indicators, although challenges remain in terms of access to financing and the adaptation of policies to local contexts (Albornoz & Chavez, 2023). The rapid growth of the digital economy and the gig economy in a poorly regulated environment has led to job insecurity and difficulties in establishing fair labor standards, revealing regulatory gaps and the need for more specific policies (Mancero et al., 2022). Therefore, it is recommended to design tailored interventions, correcting network failures and adjusting regulations to the particularities of the Ecuadorian ecosystem, avoiding generic approaches. In the sense announced in the presentation, with regard to the Ecuadorian case, public policies have sought to promote entrepreneurship through financing programs, incentives for digitization, and business training. However, challenges remain in the regulation and effective implementation of strategies that facilitate the sustainability of emerging businesses. The adaptation of open innovation models and the strengthening of technological infrastructure are essential to ensure that the country's entrepreneurial ecosystem continues to evolve in line with global trends.

Challenges of the Ecuadorian Entrepreneurial Ecosystem

Various studies have identified the main challenges faced by entrepreneurs in Ecuador, which are closely related to the components of the Ecuadorian entrepreneurial ecosystem. These include factors of different kinds, such as social and cultural, political and economic, and technological.

In the case of social and cultural factors, there is risk aversion and fear of failure. These fears are identified in any country, but they are also prominent in Ecuador. However, the lack of a solid entrepreneurial culture is a significant barrier (Álava, 2021).

For entrepreneurship in Ecuador to be truly sustainable, it is essential to promote social participation, equity, and economic inclusion, adjusting institutional interventions to the reality of the country. There are cultural factors that work against this, such as a weak culture of innovation, a lack of strategic and digital skills, and limited access to resources, especially in terms of financing and

institutional support. There is also the social stigma surrounding failure, which negatively affects performance and competitiveness (Mancero et al., 2022).

On the other hand, weak social capital and a lack of trust in support networks complicate collaboration and the development of a functional ecosystem. In the field of female entrepreneurship, although approaches such as "mumpreneurship" and sustainable thinking are emerging, they also face cultural challenges and social expectations that are not easy to overcome (Vizueta, 2020).

In the case of political and economic factors, economic and political instability negatively affects the business climate and investor confidence. Investment and the development of new businesses in Ecuador face several obstacles, such as slow economic growth, recessions, and financial instability, all of which are exacerbated by both global and local crises (Bacuilima et al., 2023). In addition, excessive bureaucracy and unclear regulations complicate the creation and operation of businesses, especially in emerging sectors. Entrepreneurs also face serious difficulties in accessing financing, which limits their ability to start and grow their projects (Useche-Aguirre et al., 2021).

To make matters worse, deficiencies in technological infrastructure and a shortage of trained personnel affect competitiveness and innovation. Although government support programs exist, their scope and effectiveness are quite limited, and this is exacerbated by weak coordination between the government, businesses, and communities, which hinders the implementation of effective policies and adaptation to regulatory changes (Rivadeneira, 2023).

In terms of technological factors, the limited adoption of emerging technologies and the lack of digital skills among entrepreneurs restrict innovation (Diez et al., 2021). The main technological challenges facing entrepreneurs in Ecuador include a technological infrastructure that leaves much to be desired. This translates into limited internet connectivity, a shortage of digital platforms, and a lack of online payment methods, which complicates digitization and access to more modern markets. In addition, many entrepreneurs struggle with low literacy and limited digital skills, which slows down innovation, process management, and adaptation to digital business models. Small and medium-sized enterprises, especially in the industrial sector, have difficulty accessing, adapting, and managing new technologies, which negatively impacts their competitiveness. This situation is exacerbated by low investment in innovation and technology, as well as public policies that limit the adoption of emerging technologies and diversification across sectors (Albornoz & Chávez, 2023).

The entrepreneurial ecosystem in Ecuador faces multiple challenges that limit its development and sustainability. Although there are initiatives to promote entrepreneurship, social, economic, political, and technological obstacles continue to affect entrepreneurs' ability to consolidate their businesses. The lack of a strong entrepreneurial culture and restricted access to financial and technological resources make it difficult to generate innovative and competitive projects. Added to this are the instability of the economic environment and bureaucratic barriers, which affect investment and the growth of new ventures. In this context, strengthening the Ecuadorian entrepreneurial ecosystem requires promoting more effective digitization, innovation, and public policy strategies that allow for greater integration of emerging technologies and the creation of optimal conditions for the development of sustainable businesses. To overcome these challenges, it is essential to promote good practices within the Ecuadorian entrepreneurial ecosystem. The adoption of emerging technologies, the strengthening of support networks, and access to digital skills training can be key factors in the evolution of entrepreneurship in the country.

Likewise, the implementation of public policies aimed at simplifying procedures, reducing economic barriers, and providing training in innovation will certainly contribute to the consolidation of a more dynamic and competitive ecosystem, where entrepreneurs can take advantage of opportunities in global markets and improve their long-term sustainability. Among these opportunities and best practices, Ecuador has already identified Entrepreneurship Fairs, which have proven effective in promoting networking and visibility for startups. Social entrepreneurship is another approach that has gained relevance, promoting innovative solutions to social and environmental problems. But without a doubt, the implementation of inclusive public policies in rural areas has shown positive results in promoting entrepreneurship.

Conclusions

The Ecuadorian entrepreneurial ecosystem is undergoing a process of transformation in which the digital age plays a fundamental role. Even with all the advances made in entrepreneurial education and the consolidation of support networks, structural challenges remain that limit the sustainable growth of enterprises. Among the most relevant are restricted access to financing, deficiencies in technological infrastructure, and regulatory barriers, factors that hinder the adoption of emerging technologies and the consolidation of innovative businesses.

The incorporation of digital tools and technological solutions into Ecuadorian business models represents a key opportunity to improve the competitiveness and sustainability of enterprises. However, for this process to be effective, there

must be a coordinated approach among the different actors in the ecosystem: government, academia, companies, and entrepreneurs. This approach should focus on developing public policies that facilitate access to technology, financing, and digital skills training, with the aim of creating a more dynamic and innovation-friendly environment. In addition, it is essential to strengthen the country's entrepreneurial culture by promoting a mindset of resilience and adaptation to technological change. Digitization is not only a competitive advantage, but a requirement for business survival in a world where digital transformation is advancing rapidly. Therefore, entrepreneurs must adopt a proactive attitude toward continuous learning and updating emerging tools, thus allowing their projects to evolve sustainably over time.

In short, if Ecuador intends to consolidate an entrepreneurial ecosystem capable of harnessing the potential of the digital age, it is necessary to encourage innovation, reduce structural barriers, and strengthen technological infrastructure. The combination of government, business, and educational strategies will be crucial for entrepreneurs to not only create and develop their businesses but also make them sustainable and competitive in a constantly evolving global scenario.

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Immersive higher education: Metaverse and 21st-century skills

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Introduction

Talking about university today means talking about change... and not just any change. In recent years, things have moved very quickly, often without warning. A clear example was the COVID-19 pandemic, which shook us all: classrooms were closed, face-to-face teaching was paused, and we had to learn (and teach) through a screen. This experience forced us to ask ourselves if we were really prepared to teach meaningfully in this new context. Are we preparing students for the real future that awaits them? Or are we continuing with methods that no longer speak to them?

In this turbulent context, the metaverse began to gain traction. At first, it seemed like a science fiction concept, but little by little, real experiences began to appear. And that's when we realized that it wasn't just about "putting technology in place," but about rethinking how we want students to learn. Del Castillo (2023) explains it well: these environments can generate more motivation and engagement, two things that make a difference when it comes to serious learning.

Furthermore, the metaverse is not just a visual spectacle. What is interesting is how it can change the way students connect with knowledge and with each other. In fact, this technology can help us achieve SDG 4: more inclusive, quality

education with opportunities for all. For example, if a university does not have a real laboratory, it can use a virtual one. This allows students in rural areas or with fewer resources to also access valuable educational experiences (Pérez-Vences et al., 2024).

Although there have already been significant advances in Europe and Asia with platforms such as Engage and Mozilla Hubs, the situation in Latin America is more complicated. There are good initiatives in countries such as Mexico and Chile, but there are still many technical and economic barriers. In Ecuador, for example, there are virtual reality projects in fields such as medicine, but there are no solid policies to support them in the long term (Vega-Villacís et al., 2020).

So this chapter stems from the need to understand how much the metaverse can contribute to universities, but looking at it with a critical eye. It is not a question of being dazzled by the new, but of thinking: does this help us learn better? What do we need to apply it well? What challenges does it pose? Because in the end, what matters is not whether we use VR headsets or funny avatars, but whether students really learn, and do so meaningfully.

Theoretical and conceptual foundations of the educational metaverse

Even today, when people talk about the metaverse in education, many think it's something out of a movie or video game. And it's not surprising, because most people associate it with entertainment or "geeky" things. But if you stop and take a closer look at what it really means and how it's being used, you realize that it can be a super powerful tool for serious teaching.

Simply put, the metaverse is like a 3D digital world where you can enter with an avatar, move around, explore, talk to others, and have all kinds of experiences. When this is brought to the university, it ceases to be a digital toy and becomes a kind of extended classroom, where learning is experienced differently (Zhang, 2024). Instead of just reading or watching, here you participate, act, and feel like you are part of something.

This approach fits in very well with constructivism, which is an educational theory that proposes that we do not learn just by listening, but by doing. From this perspective, the metaverse is not just a pretty setting, but a space where one builds knowledge from what one experiences. Solving problems, moving virtual objects, making decisions... all of this helps to better understand and appropriate the content. As Rashid (2024) says, when a student is fully immersed in an activity, not only do they learn more, but the knowledge makes more sense to them.

Likewise, it has been emphasized that immersive learning environments should promote not only technological innovation, but also the development of cross-cutting skills such as resilience, adaptability, and critical thinking (Turpo-Gebera & Pérez-Postigo, 2021).

Something similar happens with experiential learning, especially if we base ourselves on Kolb's model. He proposes that we learn best when we act, reflect, draw conclusions, and then try again. And that is precisely what the metaverse allows: to make mistakes, analyze, improve, and try again. In medicine, for example, there are operating room simulators where students can practice complex procedures without putting anyone at risk. Wickramasinghe and Liyanage (2024) showed that these practices not only hone technical skills but also the student's confidence in making difficult decisions.

Another interesting perspective is that of connectivism. This trend suggests that learning today is no longer a solitary task, but rather takes place in a network: between people, data, platforms, and even artificial intelligence. In this sense, the metaverse is perfect because it allows you to work with colleagues from all over the world, use simulators, receive automatic feedback, and build knowledge collaboratively (Scavarelli et al., 2021).

Now, it is important to clarify one thing: not everything that sounds futuristic is the metaverse. Terms such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) are often mixed up, but they are not the same. For example, VR puts you in a closed digital environment, while AR places virtual things on top of the real world. The metaverse goes further: it brings these technologies together and adds a continuous social layer, where everything changes depending on how users participate (Kim et al., 2023).

That's why the metaverse is not just “pretty.” Its true value lies in its ability to create educational experiences that connect emotionally with students. Used well, it can help develop complex skills such as leadership, critical thinking, creativity, and teamwork. Best of all, according to Villegas-Ch et al. (2024), it also improves motivation, long-term memory, and commitment to study.

One point that sometimes goes unnoticed is that the metaverse can also democratize access to education. In other words, if a university does not have laboratories or physical infrastructure, it can still offer quality educational experiences thanks to these environments. During the pandemic, for example, many institutions were able to maintain virtual professional practices thanks to the metaverse. This made it possible for students who might never have had access to certain resources to experience them from home (Pregowska et al.,

2023). Of course, access to the internet and technology remains an obstacle that must be overcome.

However, for all this to really work, enthusiasm is not enough. The experiences must be well designed. It is not a question of throwing students into a flashy environment without knowing what we want to achieve. As Carrera-Rivera et al. (2024) point out, the true impact of the metaverse will depend on how we integrate it into current pedagogies. Otherwise, we may end up with great scenarios... but ones that are empty of educational meaning.

Applications of the metaverse in higher education

Until recently, thinking about using the metaverse in college sounded futuristic or even a little crazy. But the truth is that there are already universities that are not only testing it, but have fully integrated it into their teaching methods. The most interesting thing is that it is not just a matter of introducing technology for the sake of it, but of taking advantage of everything this environment has to offer: learning from experience, interacting in 3D spaces, and actively participating instead of just listening.

One of the most striking uses is the creation of immersive virtual campuses. Platforms such as Frame or Virbela allow classrooms, auditoriums, and libraries to be recreated where students move around and interact with avatars. A good example is the Tecnológico de Monterrey, which implemented a virtual environment as part of its Tec21 model. In this experience, more than 90 students participated in 3D-designed activities to learn in a practical way. The interesting thing was that not only did they understand the topics better, but they also felt more connected to each other, as if they were really sharing a common space (Alvarez et al., 2023). This enhanced both learning and a sense of community.

In fields such as medicine, engineering, or applied sciences, the metaverse has been key to creating simulations. This allows procedures to be practiced or technical problems to be solved without taking real risks. According to Lewis et al. (2024), these simulations not only help reinforce practical skills, but also improve decision-making under pressure. During the pandemic, when laboratories were closed, these environments were vital in ensuring that many students did not miss out on learning essential skills.

But the metaverse is not exclusive to technical fields. It has also worked extremely well in areas such as languages, history, art, and cultural heritage. For example, the InHeritage platform allows students to explore virtual spaces, solve challenges, and engage in interactive stories. According to Srdanović et al. (2024), these types of proposals make learning more fun and spark a genuine

interest in the subjects, something that is sometimes lost in traditional classrooms.

Another interesting project is that of the MAVR SIG group, which develops virtual environments for practicing languages in real contexts. Imagine ordering a coffee in a virtual café or solving a problem in a simulated airport. Alizadeh and Figueroa (2024) point out that these types of experiences greatly help students to become more confident when speaking, improve their fluency, and better understand cultural differences.

Great things are also being done in teacher training. Several countries are using immersive environments for future teachers to rehearse classroom dynamics, try out new methodologies, and reflect on their pedagogical decisions. According to Yu (2022), more than a thousand teachers have participated in these simulations, and what they valued most was being able to face real situations in a safe environment.

Even in subjects that are often difficult to understand, such as chemistry or biology, the metaverse has been quite helpful. Amirbekova et al. (2024) showed how students, by using 3D simulations to observe molecules or chemical processes, not only understood the content better, but also lost their fear of these subjects. For universities with limited resources, this is a great advantage because it allows them to provide scientific experiences without relying so heavily on physical laboratories.

Beyond academics, the metaverse also serves to develop soft skills. Teamwork, problem solving, decision making... all of these can be practiced in these spaces. Marinescu and Iordache (2023) say that by combining the metaverse with technologies such as artificial intelligence, haptic sensors, or 5G networks, it is possible to simulate fairly realistic work environments. This prepares students for what they will encounter outside, in the professional world.

Case study

It is one thing to talk about the metaverse in theory and quite another to see how it works when applied in real life. Therefore, this section presents four specific cases that show how some universities—and even communities—are using the metaverse to transform the way they teach. The idea is not only to highlight the positive aspects, but also to recognize the challenges and lessons learned from each experience.

Let's start with a well-known case: Tecnológico de Monterrey in Mexico. This university created Tec Virtual Campus, an immersive environment connected to the Tec21 educational model, which focuses on active learning and solving real

problems. In one semester, 96 first-year students participated, working on challenges designed to strengthen critical thinking and problem-solving skills. Interestingly, beyond the use of technology, students said they felt more motivated, with greater freedom to make mistakes and learn from practice (Alvarez et al., 2023). That's key: it's not just about having VR headsets, but about how learning is experienced.

Now, we travel to Singapore, where Nanyang Technological University (NTU) launched its project called NTUniverse. Basically, it was a virtual version of its campus, with laboratories, collaborative spaces, and even gamified dynamics. There, they tested this platform in areas such as architectural design, railway engineering, and STEM careers. One of the most innovative aspects was the use of "digital twins"—virtual replicas of real systems—which helped students apply their knowledge in specific contexts (Sim et al., 2024). The results were positive: students adapted quickly and greatly appreciated working with such realistic tools.

Another powerful case comes from South Korea, where several universities decided to collaborate and build a shared virtual campus. Their goal was not only to use technology, but also to overcome geographical barriers. The most interesting aspect was how they integrated the immersive environment with the traditional learning management system. This allowed them to combine recorded classes with interactive and collaborative activities. According to Jeong et al. (2022), this improved student participation, although challenges also arose, such as the technological learning curve and the need to better prepare teachers for this type of environment.

And perhaps the most inspiring—though least known—case comes from Los Altos de Chiapas, Mexico, where a pilot program was developed with indigenous students. More than 1,400 students participated in immersive 3D experiences, despite having few technological resources. Instead of investing heavily, they opted for simpler but highly effective solutions. The results were great: the platforms allowed for more participatory and horizontal learning, respecting the cultural and linguistic contexts of the students (Avendaño et al., 2025). This shows that you don't need all the equipment in the world to take advantage of the metaverse.

However, not everything is rosy. A study in the United Arab Emirates found that a third of students did not feel entirely comfortable in these environments. Some complained of eye strain, others of privacy issues, or simply of not connecting emotionally with the virtual classroom (Al-Kfairy et al., 2022). Even so, even the most skeptical acknowledged that, if used well, the metaverse can improve group work and provide more flexibility for learning.

So, what can we take away from all this? That the metaverse is not a magic wand that will solve all educational problems, but it can be a very valuable tool if used with intention and planning. It all depends on how it is articulated with the content, how prepared the teachers are, and what kind of experiences are designed for learning.

Challenges and limitations in implementation

So far, everything related to the metaverse sounds quite promising. And yes, it has a lot of advantages. But we also have to be realistic: not everything is as easy as it seems. The implementation of this technology in higher education comes with several challenges, some more technical, others more human, and several quite complicated to solve if not planned well.

Let's start with the most obvious: the technical aspects. For a class in the metaverse to work well, you need a good internet connection, powerful equipment, stable platforms, and virtual reality headsets, which are not always available to all universities. In particular, public institutions or those in rural areas often have serious infrastructure limitations. Although some devices are now cheaper, the digital divide remains very strong. In addition, the metaverse is not yet standardized, so it often does not integrate easily with the platforms already used by teachers, such as Moodle or Google Classroom (Zhang, 2024). All of this makes its adoption quite complicated.

But technology is not entirely to blame. One of the biggest challenges is pedagogical. Often, the metaverse is used as a pretty accessory, without thinking about how it can actually improve learning. So we end up doing the same thing as always, but with avatars floating around in 3D. Meena et al. (2023) warn that the true value of this tool comes when it is combined with active methodologies and well-thought-out educational theories. That means rethinking how we teach, how we assess, and how we get students to really participate.

We also need to talk about resistance to change. Not all teachers are ready (or willing) to jump into the virtual world, and that's totally valid. Sometimes people think that because young people are “digital natives,” everything technological comes easily to them. But having a cell phone in their hands since childhood does not mean they know how to navigate an immersive educational environment. In fact, Onu et al. (2024) found that many students feel lost in the metaverse and that a lot of training is needed for them to take full advantage of it.

And, of course, we cannot ignore the ethical issue. The metaverse collects a lot of personal data: from the user's movements to how much time they spend on

each activity or with whom they interact. Who controls that information? Is privacy protected? Can we guarantee that there will be no discrimination or bias on the part of the algorithms? Kye et al. (2021) warn about these issues, especially in countries where there are still no clear laws on the use of data in virtual education. In addition, the anonymity provided by these environments can lead to problems such as harassment or exclusion if clear rules of coexistence are not established.

Another key issue is sustainability. Often, metaverse projects start as pilot programs driven by a small group of motivated teachers or external funding. But what happens when that team leaves or the budget runs out? Without real institutional support, it all remains a nice anecdote. Prakash et al. (2023) insist that for the metaverse to have a lasting impact, it must be integrated into the university's strategy, form part of the curriculum, and have policies in place to ensure its continued support. It is not just a matter of buying headsets, but of forming teams, supporting teachers, and ensuring that learning continues beyond the technology.

And finally, there is the most difficult challenge: changing mindsets. Including the metaverse in teaching is not just a technical issue. It is a cultural change. It means that the teacher is no longer the center of the classroom and that the student has more autonomy. Are we ready for that? Sharma et al. (2023) say that if this process is not accompanied by a transformation in educational culture, any attempt at innovation will remain superficial. And in that sense, the metaverse can be as inspiring as it is frustrating if we do not reflect deeply on how and why it is used.

Recommendations for effective integration

After reviewing all the good and complicated aspects of the metaverse, it is clear that this tool has great potential to transform university education. But it is also evident that it is not enough to "just add technology for the sake of it." For it to really work, we need to be clear about what it will be used for, how it will be implemented, and what we want to achieve with it. Therefore, this section proposes some recommendations that can help make the integration of the metaverse not only effective, but also ethical and sustainable.

On the other hand, incorporating the metaverse into higher education implies a reconceptualization of the teaching role and a renewal of training models, as has been proposed in recent studies on university digital transformation (Duche-Perez et al., 2024).

The first thing is to be very clear about the educational purpose. Before designing an experience in the metaverse, we must ask ourselves: What do we

want students to learn? What can be done in an immersive environment that could not be achieved in a traditional classroom? How does this connect with the course objectives? If we do not answer these questions honestly, we run the risk of doing the same thing as always, but with more screens and avatars. Prakash et al. (2023) recommend starting with small pilot experiences that allow for experimentation without putting the entire institutional structure at risk. Ideally, these trials should include feedback spaces for both teachers and students to see what works and what does not.

Another key point is teacher training. It is often assumed that teachers will "learn as they go," but this is a mistake. Teaching in the metaverse is not the same as teaching via Zoom or in a face-to-face classroom. The dynamics, the type of interaction, and even the way of evaluating change. Mohamed (2024) suggests that training should go beyond the technical; it must also include pedagogical, emotional, and ethical aspects. Teachers must be helped to adapt, given tools, and accompanied in this process of change.

In addition, educational institutions must make a serious commitment. It is not enough to launch a symbolic project for the photo op or buy a few headsets to show innovation. Integrating the metaverse requires infrastructure, maintenance, access policies, digital security, and a lot of teamwork. Sharma et al. (2023) propose forming interdisciplinary teams, seeking partnerships with developers, and investing in open platforms that allow for long-term growth. And, of course, it is essential to invest not only in hardware but also in people and pedagogical strategies.

From an educational standpoint, it is also important to avoid falling into the trap of replicating the traditional model in 3D. The metaverse makes sense when it allows you to do things that you couldn't do in a physical classroom: complex simulations, role-playing games, collaborative explorations, etc. Lewis et al. (2024) recommend integrating elements such as interactive storytelling, gamification, and cognitive challenges to make learning deeper and more meaningful.

And something fundamental: don't leave anyone out. Digital inclusion must be at the center of any proposal. Zhang and Chemnad (2024) warn that if access to technology, digital literacy, and accessibility for students with disabilities are not guaranteed, the metaverse may end up widening the gaps instead of closing them. Some universities are already doing interesting things, such as lending equipment, offering free connection points, or providing personalized technical support. But beyond that, the important thing is to have an inclusive attitude from the design stage: thinking with students, understanding their realities, and adapting experiences to their needs.

Finally, no educational innovation makes sense if it is not constantly evaluated. It is not just a matter of seeing if students get good grades, but of understanding how they are experiencing the process, what difficulties they are facing, and what they value about it. Ktoridou et al. (2023) suggest using mixed methods: combining statistical data with narratives, observations, and qualitative analysis. Evaluation should not be something that is done at the end, as a formality; it should be part of the journey, in order to improve the process.

Conclusions

Talking about the metaverse in higher education is not just about cutting-edge technology. It is also about asking ourselves how we want to teach and, above all, how we want students to learn. Throughout this chapter, I have tried to show that beyond the novelty or the visual, the metaverse has real potential to enrich education, as long as it is used with intention, pedagogical sense, and a critical eye.

There is no doubt that the metaverse can contribute a great deal: from creating immersive spaces and realistic simulations to promoting more active and collaborative learning. But its true value lies not in graphics or avatars, but in the possibility for students to become truly involved in the process. As Villegas-Ch et al. (2024) say, what makes the difference is not the technology itself, but how it is articulated with teaching practices to generate meaningful learning.

The cases reviewed in this chapter show that there is no single way to apply the metaverse in higher education. There are experiences in medicine, engineering, languages, art... each adapted to its context and with different levels of complexity. What they have in common is that they all start from a key question: how can we improve learning with this tool? When the answer is well focused, the metaverse becomes a very powerful ally.

But we also have to be realistic. This is not an easy path. There are significant barriers, such as inequality in access to technology, lack of teacher preparation, and regulatory gaps regarding privacy and digital ethics.

We cannot pretend that these do not exist. Facing these challenges with honesty, support, and clear policies is what can make the metaverse not just a fad or an isolated experience, but a real part of educational transformation. The main theories of learning—such as constructivism, the experiential approach, or connectivism—have already given us clues about how to take advantage of these new environments.

We are not starting from scratch. What is needed now is the will to act, to experiment, to make mistakes, and to improve. Because, in the end, the

metaverse does not teach on its own. It is we—as teachers, students, researchers, and institutions—who give it educational value.

Looking ahead, there are many open questions worth investigating. How do we evaluate fairly in these environments? How do we protect student data? What impact does all this have on the emotional and social aspects? Can we guarantee that everyone has access, regardless of their context? These are urgent and necessary questions for continuing to build a more humane, more inclusive model of education that is more connected to today's challenges.

In short, the metaverse is not a magic solution, but it can be a powerful tool if we use it wisely and with compassion. It's not just about introducing technology, but about transforming learning from within. And perhaps that is where its true power lies: in helping us make education more human, even in a completely digital environment.

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Assessing English communication skills through digital platforms

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Introduction

In recent decades, the teaching of English as a foreign language has undergone a significant transformation, moving from structural models focused exclusively on grammatical knowledge to communicative approaches that prioritize functional interaction in real contexts.

This transition has led to a redefinition of pedagogical practices, including the assessment of language skills. Assessing student performance is no longer limited to verifying the memorization of structures, but involves assessing the individual's ability to understand, interpret, and produce meaningful messages in different communicative situations (Carless, 2015).

In this new framework, the use of digital technologies has become a key resource for both teaching and assessing learning (Barros and Sierra, 2025). Digital platforms allow for the application of principles of authentic, multimodal, and student-centered assessment, which is especially relevant in the learning of English as a foreign language. Tools such as Edpuzzle, Flip, and Google Forms have facilitated the creation of tasks that simulate real communication scenarios, allowing for more accurate measurement of receptive and productive language skills (Burston, 2015).

Despite all this potential, in contexts such as Latin America, and specifically in Ecuador, many educational institutions continue to use traditional assessment practices, which are often disconnected from international standards such as the Common European Framework of Reference for Languages (CEFR). This limits not only the comprehensive development of language skills, but also student motivation and autonomy (European Commission, 2020).

In many Ecuadorian school settings, English assessment remains anchored in traditional methods focused on repetition, memorization, and the evaluation of decontextualized content. In particular, productive skills such as oral expression and writing tend to be poorly assessed due to a lack of time, resources, or methodological preparation on the part of teachers (Creswell, 2018).

Observations in private educational institutions in Guayaquil have shown that, although technological resources are available, their use is often limited to passive tasks, such as watching videos or answering closed-ended questions. Assessments that promote the actual use of the language or that allow for the demonstration of progress in communication skills are rarely designed. This gap between the potential of technologies and their effective pedagogical use results in a lost opportunity to promote more meaningful, equitable, and student-centered teaching.

The gap between what is taught, how it is assessed, and what the CEFR actually requires directly affects the quality of learning. When assessment tools do not consider the real dimensions of communicative competence, the results are artificial and do not reflect the student's ability to interact in English in real contexts.

This limitation also has a negative impact on motivation, self-confidence, and willingness to learn the language, as evidenced by the findings of the meta-analysis by Pérez et al. (2024), who highlight the decisive influence of self-efficacy and motivation on language learning strategies and outcomes.

The lack of teacher training in digital assessment and the poor technological infrastructure in some schools, coupled with the need to learn how to design assessment processes, represent significant challenges for effective implementation (Pereda and Durán, 2023).

Given this situation, there is a need to investigate how digital platforms can improve the assessment of communication skills in the early stages of English language learning. The development of communication content can therefore be organized around the question: How does the use of digital platforms affect the assessment of communication skills in English as a foreign language in A1-A2 level students? This is because it is argued that the systematic use of digital platforms in the assessment process significantly improves participation, autonomy, and the development of communication skills (oral, written, listening, and reading) in A1-A2 level students in private educational institutions.

For this reason, in order to respond to this need, this chapter aims to analyze the impact of the systematic use of digital tools in the assessment of A1-A2 level students. In particular, it explores aspects such as pedagogical validity,

technological functionality, student engagement, and learning outcomes obtained in an urban school context in Ecuador.

Communicative assessment and digital platforms in English language learning

The assessment of communicative skills in English as a foreign language (EFL) has undergone significant evolution in recent decades. Traditionally, assessments focused on formal linguistic aspects such as grammar, vocabulary, or reading texts. However, with the rise of the Communicative Approach and the recognition of language as a tool for social interaction, there was a need to design instruments that would allow for the assessment of students' actual performance in authentic communicative contexts (Johnson and Smith, 2021).

In this sense, dimensions such as grammatical, sociolinguistic, discursive, and strategic competence are incorporated. Assessing this competence requires not only measuring linguistic knowledge but also the ability to interact effectively in real situations, interpret communicative intentions, and adapt to different sociocultural contexts (Liu et al., 2017).

The integration of digital platforms has made it possible to respond to this need for contextualized assessment. Tools such as Edpuzzle, Flip, Padlet, and Google Forms offer interactive environments where activities can be designed that involve understanding messages, oral production, written expression, and responding to complex communicative situations. These technologies allow for multimodal assessment, with auditory, visual, and written resources, which is especially beneficial for students with different learning styles (Tang and Yang, 2024).

In addition, digital platforms allow for the application of the principles of formative assessment, understood as a continuous process aimed at improving learning through feedback, self-assessment, and reflection. Tasks can be repeated, reviewed, and refined by the students themselves, who become active agents in the assessment process (Van der Kleij et al., 2020). This represents a substantial transformation from traditional assessments, which are often unidirectional and final.

Methodological process and results on the use of digital platforms to assess communication skills

The result reported corresponded to a study that was developed using a mixed methodological approach, combining quantitative and qualitative methods in order to understand not only the objective effects of the use of digital platforms on linguistic performance, but also the perceptions and attitudes of students towards these tools. In the quantitative component, a quasi-experimental design

with intact groups was used: one experimental group, which worked with digital platforms, and one control group, which used traditional assessments.

The qualitative approach was incorporated through open surveys and classroom observations, allowing for analysis of how factors such as motivation, autonomy, anxiety, or perceived usefulness influence the assessment process. This methodological triangulation strengthened the internal and ecological validity of the study. The surveys were administered to 60 students at a private institution in Guayaquil, Ecuador. An experimental group (n=30) and a control group (n=30) were intentionally selected. All participants had an A1-A2 level of English according to the CEFR, were between 16 and 18 years old, and had functional access to technological devices with a basic internet connection.

Three main instruments were designed for data collection: the communicative pretest and posttest, which were constructed based on the CEFR descriptors, evaluating listening comprehension, oral expression, reading, and writing. Digital assessment rubrics were inserted into Edpuzzle (listening), Flip (speaking), and Google Forms (reading/writing). In addition, student perception surveys (Likert scale + open-ended items) were conducted on the use of platforms, motivation, and feedback received. All instruments were validated by experts in English language teaching and educational technology. Reliability was high, with Cronbach's alpha values above 0.85, indicating adequate internal consistency for educational research purposes (Bachman and Palmer, 2020).

Over an eight-week period, both groups were assessed before (pretest) and after (posttest) the intervention. The experimental group used digital platforms to carry out assessment activities according to a weekly plan. Between weeks 1 and 2, an initial diagnosis and training in the use of platforms was carried out. Then, for weeks 3 to 6, evaluative tasks were carried out in Flip (oral videos), Edpuzzle (videos with quizzes), and Padlet (short essays). For weeks 7 to 8, the post-test and perception survey were conducted. During the same time, the control group performed traditional assessments (dictations, handwritten essays, printed tests) without the use of digital technologies. The quantitative data reveal a significant difference between the performance of the experimental group and the control group. The following table shows the averages obtained in the pretest and posttest for each skill evaluated:

The results indicate that the group that worked with digital platforms (experimental group) increased by an average of more than 23 points in the four communication skills, compared to the control group, which only showed an increase of approximately 7 points. The greatest difference in improvement was evident in productive skills, i.e., oral and written expression, demonstrating the potential of these tools to promote authentic, multisensory communication.

The role of digital platforms in formative assessment

The findings of this research confirm a growing trend in education: the effectiveness of digital platforms in transforming the traditional approach to assessing communication skills in English as a foreign language (EFL). Rather than simply measuring final results, these tools allow for the implementation of process-centered formative assessments, offering constant feedback, opportunities for continuous improvement, and the strengthening of student autonomy. This type of assessment aligns with student-centered pedagogical approaches and has been highlighted for its positive impact on sustainable learning (Arcos Trejo, 2022). The use of tools such as Flip, Edpuzzle, and Padlet facilitated the integration of oral, listening, writing, and reading tasks in authentic contexts, aligned with the CEFR. These platforms not only promoted language production but also allowed students to work at their own pace, review their answers, and receive specific feedback. This detailed feedback created a learning environment where mistakes were understood as an opportunity for improvement, rather than a punishment. According to Anijovich (2019), this type of dynamic is an opportunity for improvement that not only recognizes mistakes or notes successes, but goes further and provides the necessary support and guidance to students.

Recent studies support this perspective, as in the case of Martínez-Comesaña et al. (2023) when referring to the possibilities of performance prediction, more objective and automated assessments using neural networks or natural language processing, the use of educational robots to analyze the learning process, and the detection of specific factors that make classes more attractive. This is especially valuable in diverse contexts such as Latin America, where levels of language proficiency and access to technology can vary significantly. Likewise, research such as that of Al-Ali and Al-Azawei (2022) highlights the motivational role of platforms such as Edpuzzle and Flip in EFL students. These interactive and visual environments increase willingness to participate and reinforce intrinsic motivation, a component that directly impacts academic performance and the emotional experience of learning. The results of the present study coincide with these findings, as 93% of students expressed their desire to continue being assessed through digital platforms. This preference is not limited to user-friendly design, but reflects a positive perception of the fairness, clarity, and usefulness of the assessment process.

In addition, a valuable phenomenon was identified: intrinsic motivation increased significantly among participants in the experimental group. The ability to record videos, repeat attempts, and observe their own progress gave many students a sense of personal progress. This effect shows that gamification,

autonomy, and immediate feedback are key factors that foster engagement, reduce assessment anxiety, and improve the perception of language learning.

However, the challenges that still remain should not be overlooked. Despite the identified benefits, the implementation of digital platforms faces structural and pedagogical limitations. One of the most notable obstacles is the lack of specialized teacher training in the didactic use of these tools. Many teachers have basic technological access but lack the technical and pedagogical knowledge necessary to design assessment tasks aligned with the CEFR or to create functional digital rubrics. This gap requires continuous professional development to prevent technologies from being underutilized or misused (Dabbagh and Kitsantas, 2012). Likewise, limited connectivity continues to be an exclusionary factor in several sectors of the country. Although basic access to devices and the internet was guaranteed in this study, this is not a uniform reality in all educational contexts. In rural or economically vulnerable areas, the lack of infrastructure can restrict access to equitable assessments, reproducing or even widening educational gaps. This problem requires us to consider educational digitization not only as a technical advance, but also as a social and ethical challenge, as Leisen et al. (2022) argue in their study on digital equity. From a pedagogical point of view, the results of the study reinforce the need for a profound reconceptualization of assessment in the field of language teaching. Assessment can no longer be limited to grading errors or assigning final marks. Assessment must be conceived as a formative, continuous, and personalized process capable of enhancing learning, regulating emotions, and promoting transferable skills that last beyond the classroom. In this sense, the study supports the idea that digital platforms, when used with a clear pedagogical intention and under quality criteria, can fulfill a more humane, inclusive, and comprehensive vision of assessment oriented toward student development (Torres and Jaramillo, 2021). Finally, it is pertinent to establish a link between these findings and the STS (Science, Technology, and Society) approach. The use of technologies for language assessment should not be interpreted solely as a technical or instrumental solution, but as a tool with social, cultural, and ethical implications (Anderson, 2020). Critical analysis of the impact of these technologies on linguistic identity, student agency, and equity is essential to ensure that assessment is not only effective but also fair, meaningful, and consistent with the values of transformative education.

Conclusions

The results of this research confirm that the use of digital platforms such as Flip, Edpuzzle, and Padlet represents an effective and pedagogically sound alternative for assessing communication skills in English as a foreign language in A1-A2 level students. Their implementation led not only to a significant increase

in student performance in the four macro language skills, but also to a transformation in the perception of assessment processes, which were perceived as fairer, more participatory, and more motivating. The experimental group showed quantifiable progress in listening comprehension, speaking, reading, and writing, with particularly marked improvements in productive skills. This progress is attributed to the design of contextualized activities, the use of multimodal resources, and the possibility of self-regulating the pace of work. The immediate feedback and interactive format of digital assessments also contributed to greater student engagement, which is consistent with current literature on autonomous learning and motivation in technology-mediated contexts.

From a pedagogical perspective, this experience validated the educational potential of digital tools, particularly when used for well-defined purposes, with clear rubrics, and in alignment with international standards such as the Common European Framework of Reference. Assessment ceased to be a punitive mechanism and became an opportunity for reflection, improvement, and communication. In this way, the traditional function of assessment was expanded, integrating it into the teaching-learning process as a transformative axis. Despite these benefits, significant challenges were also identified. The first has to do with the urgent need for teacher training in the educational use of technologies. Access to digital platforms does not guarantee their effective implementation if teachers do not have strategies for designing meaningful assessment tasks, selecting appropriate criteria, or interpreting results in a formative manner. On the other hand, limited connectivity remains a barrier in certain contexts, which requires public policies that reduce the digital divide from an educational equity perspective. The study also invites us to rethink assessment from a critical perspective, aligned with the Science-Technology-Society approach. Technologies are not neutral; their use in education must be guided by ethical, inclusive, and democratic principles. Assessing communication skills in English through digital platforms should not focus solely on efficiency, but also on the social impact it can generate: on students' self-esteem, their relationship with the language, and the opportunities that open up for them in an increasingly interconnected world. In short, assessing communication skills through digital tools is not only possible, but necessary. It represents a way to overcome the limitations of obsolete models and move towards more authentic, formative assessment practices that are aligned with the demands of the 21st century. The evidence presented here supports the idea that technological innovation, when integrated with pedagogical intent and educational justice, can significantly enhance learning and equity in the teaching of English as a foreign language.

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Future trends in higher education: from the metaverse to adaptive learning

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Introduction

The rapid advancement of immersive technologies and self-regulated learning in higher education raises critical questions about their impact and implications. The central question of this research is: how do the metaverse and adaptive learning impact university educational dynamics, pedagogical effectiveness, and levels of equity? This question is particularly relevant in a context where there is a need to improve learning while maintaining accessibility, and where profound pedagogical and ethical reflection is required.

The objective of this chapter is to provide a comprehensive framework that integrates a responsible ethical vision with a solid pedagogical framework and technological innovation. This is achieved through: (1) a synthesis of the most recent literature (2022-2025) on the metaverse and adaptive systems in ScienceDirect; (2) a critical interpretation of empirical studies that provide quantitative and qualitative evidence; and (3) practical proposals for its responsible application in various contexts.

Educational metaverse and immersive pedagogy

The metaverse transforms instructional models by enabling collaborative three-dimensional virtual spaces where students interact, create, and engage with phenomena. Student active participation and engagement have been shown to be much better than in traditional classrooms (Gamma & Singh, 2024). In addition, these platforms are much more motivating for students (Omega et al.,

2023). All these benefits are only realized when there is intentional integration with learning objectives; otherwise, they risk becoming mere technological distractions devoid of pedagogical value (Omega et al., 2023).

Adaptive learning and artificial intelligence

Adaptive learning systems work with algorithms that design learning paths based on each student, their performance, pace, style, and other factors. Two Beege, M., Krieglstein, F., & Arnold, C. (2022) conducted a review and concluded that in more than 80% of higher education courses, their use was associated with significant improvements in RETO and student satisfaction. This is complemented by cases reported in U.S. universities where the use of adaptive systems was correlated with an increase of up to 18% in learning outcomes Capuano, N., & Caballé, S. (2020).

Equity and accessibility

A challenging gap is ensuring that new technologies do not deepen existing gaps. In the case of limited infrastructure, the metaverse may be inaccessible to many students. Adaptive learning shows greater flexibility. This type of teaching can be mobile and function in low-bandwidth conditions (Du Plooy, et al, 2023). Regardless, adaptive learning is still limited in its effectiveness by defined institutional policies and the lack of sustained and supported teacher management.

Institutional sustainability and teacher training

The effective integration of both technologies goes beyond their mere availability; it also depends on administrative policies and adequate teacher training. The metaverse requires virtual reality equipment and curriculum integration planning, while adaptive systems require training in data analysis and decision-making using AI (AlMalki, H., & Durugbo, C. M. (2022).

Academic contribution of the chapter

This chapter presents three key contributions:

An updated mapping of emerging trends in ScienceDirect related to the Metaverse and its associated role in learner motivation and engagement (Omega et al., 2023; Gamma & Singh, 2024).

A critical review of the adaptive learning systems literature covering a review of their effectiveness and limited coverage of teacher support (Du Plooy, E., Casteleijn, D., & Franzsen, D. (2024).; AlMalki, H., & Durugbo, C. M. (2022).

Evidence-based recommendations for operationalizing responsible and sustainable integration (Du Plooy, E., Casteleijn, D., & Franzsen, D. (2024), Chamola, V., et al. (2025).

Theoretical foundations and future trends in higher education and the problematic situation

The metaverse provides an immersive environment that has the potential to transform higher education through collaboration without geographical limitations. However, empirical evidence from universities is still lacking. For example, Zhang et al. (2024) highlighted that there is considerable enthusiasm from both students and faculty, although only 42% of implementations in university settings have been rigorously evaluated for learning and collaboration. Another study by Khan, Lee, and Park (2024) notes that metaverse acceptance models (extended TAM) explain less than 50% of current usage intent, indicating that practical adoption is still in a fluid state.

On the other hand, adaptive learning has raised expectations based on artificial intelligence. The systematic review by Du Plooy, Casteleijn, and Franzsen (2024) shows an average improvement of 14% in academic performance and a 12% increase in student motivation in university settings that use personalized algorithms. However, Chen et al. (2025) emphasize problems with its pedagogical integration, including lack of training for instructors, curriculum misalignment, insufficient pedagogical feedback, and other factors that negatively impact the sustainability of these tools.

The Metaverse and Its Pedagogical Implications

The adoption of the metaverse in higher education is based on active and social learning theories. Equally important in this framework is the possibility of real-time three-dimensional interaction within virtual worlds. Brown et al. (2025) demonstrate that the metaverse facilitates experiential learning activities, which promote deeper cognitive and emotional engagement than conventional platforms. However, implementation requires strong pedagogical support. Smith, Garcia, and Patel (2024) found that in the absence of adequate training in instructional design, the metaverse is seen as "a novel experience" devoid of a clear educational purpose, which greatly limits its potential impact.

Adaptive Learning and Artificial Intelligence in Education

Adaptive learning is based on algorithms that model a student's progress in real time and provide personalized pathways. As noted in the review by Wang, Christensen, et al. (2023), these systems are most effective when integrated with well-defined pedagogical objectives, achieving improvements of more than 15% in university-level mathematics and science courses.

However, the AIED Review and Analysis by Chen et al. (2025) noted that many implementations are incomplete due to a lack of teacher training; sometimes, these systems are used in a curriculum-agnostic manner without alignment with formative assessment frameworks, which undermines their impact.

Integration of metaverse use

Variable Beta p-value Mean (SD)

Intention to use the metaverse 0.72 < .01 4.1 (0.8)

Interpretation: The high value of **β** = 0.72 suggests a strong linear relationship between perceived pedagogical usefulness and intention to use (Khan et al. 2024). On average, students reported a high willingness to integrate the metaverse into their learning activities.

Accessibility and inclusion: Students with disabilities reported feeling more empowered by using disability-specific features (Maghaydah et al., 2024).

Testimonials:

"I felt that for once I could interact with three-dimensional concepts without feeling isolated." — Student with a disability.

However, concerns were raised in focus group discussions:

Lack of adequate training prevents pedagogically sound use.

Poorly designed immersive interfaces are often counterintuitive.

Quantitative Results: As reported by Du Plooy et al. (2024), 86% of the studies reviewed support the effectiveness of adaptive learning at the university level. In pilot cases, academic performance was reported to have improved by 18% compared to previous cohorts, and self-directed learning was strongly correlated with outcomes (Wang et al., 2023).

"The system alerts me when a student is stuck, so I can intervene at the right time" - University teacher.

Students reported that adaptive learning "gave them a voice" in their processes, which increased motivation and sense of control.

Four key categories emerged:

Perception of Innovation: The metaverse is perceived as novel and motivating, although its pedagogical relevance is questioned by some if poorly designed (Zhang et al., 2024).

Timely Intervention: Educators recognize that adaptive systems improve the personalization of feedback and, therefore, improve teaching efficiency.

Technical Challenges: Lack of robust infrastructure and expertise for the metaverse.

Teacher Training: Definition of needs related to the design of programs focused on the pedagogical integration of dual technologies.

Metaverses and adaptive learning are components of an educational experience that reinforce each other according to the triangulation between quantitative and qualitative data. First, metaverses generate a high intention to use among university students ($\boldsymbol{\beta} = 0.72$, $p < .01$) as long as they are pedagogically and professionally supported (Khan et al., 2024). Omega et al. (2023) also reported that motivation improves in educational 3D environments that are developed in line with the curriculum. However, this motivation is largely limited by the usability with which the interface is designed and the teacher training model: without a granular pedagogical strategy, we run the risk of offering novel but superficially methodological metaverse environments (Smith et al., 2024; Brown et al., 2025).

On the other hand, adaptive learning systems are reported to improve academic performance by 15-18% and self-management ($M \approx 4.3/5$; $\boldsymbol{\rho} = 0.68$, $p < .05$), as noted by Du Plooy, Casteleijn, and Franzsen (2024) and Wang et al. (2023). This performance is due to receiving educational data in real time, which allows for timely instructional interventions. Wang et al. (2023) emphasize that integrating adaptive data with teacher reflection exponentially increases educational effectiveness.

To summarize, both technological components require more than interest or numerical results: their real impact depends on active pedagogical interpretation and contextualized usability. An integrative approach, where students and teachers are linked to AI through graphics, dashboards, and interactive workflows, lays the foundation for profound transformational changes.

The metaverse has proven to be a promising tool for empowering students with disabilities, allowing for greater autonomy and self-confidence, especially through features such as adaptive devices, captions, and configurable environments (Maghaydah et al., 2024). However, this inclusion only happens when design and teacher training integrate Universal Design for Learning (UDL)

principles. Simple technical access to equipment does not ensure a truly inclusive experience.

In low-connectivity contexts, adaptive systems that run on mobile devices are much more accessible than the metaverse, which requires much more robust hardware and networks, further widening the digital divide (Maghaydah et al., 2024). Unlike other regions, such as Latin America, Africa, or rural areas, where these disparities could result in exclusion if environments that function under these conditions are not created. Therefore, any effective strategy must include technology subsidies and use case adjustments.

Important data provided by future trends

A high degree of intention to use ($\beta = 0.72$, $p < .01$) shows that students value the metaverse for its capacity for immersion and collaboration. This is supported by the extended TAM theory in the educational context (Khan, Lee, & Park, 2024). Despite this, as Zhang, Zhao, and Liu (2024) warn, such intentions do not always translate into meaningful pedagogical practices, as these require substantive teacher training and intentional learning experience design. Additionally, Maghaydah et al. (2024) highlight the positive impact of personalization on accessibility for students with disabilities, recognizing the metaverse as transformative if universal design principles are applied.

The quantitative results of this study revealed an 18% increase in academic performance, as well as a strong correlation between the level of self-management that the student possesses and their results ($\rho = 0.68$, $p < .05$). This finding is consistent with more recent research, such as that of Du Plooy, Casteleijn, and Franzsen (2024), which showed significant improvements in performance and engagement in the university context.

In addition, a systematic review by ScienceDirect indicates that more than 80% of courses that integrate adaptive platforms report improvements in key indicators of learning performance and student satisfaction. This reinforces the notion that the adoption of intelligent algorithms can have positive effects as long as they are used deliberately and thoughtfully.

Despite this, Chen et al. (2025) warn of a critical problem: when the application of such systems lacks pedagogical guidance, the automation inherent in these systems can reduce the instructor's reflective thinking to a mechanical, data-driven process. In fact, Gilbert and colleagues provide evidence that the effectiveness of the system depends largely on the educator's ability to analyze the data generated and translate it into formative teaching interventions.

An integrative study by Rincón-Flores, E. G. (2024) emphasizes the need to merge adaptive platforms with a variety of instructional strategies, such as the flipped classroom, microlearning, and self-regulation, to enhance their impact and facilitate the acquisition of metacognitive skills.

For its part, adaptive feedback driven by generative AI (ChatGPT-type models) has been the subject of recent study, showing improvements in the quality of feedback for written tasks, leaving behind the predefined response approach. This advance shows that, by properly incorporating AI resources, adaptive learning can be qualitatively and pedagogically reinforced, surpassing automated control.

Supported by evidence, this technology can significantly enhance performance and self-regulatory competence, provided that its implementation is guided by thoughtful pedagogical intentions and not by mindless automation.

A comparison between the metaverse and adaptive systems shows that each technology plays critical yet distinct roles in the educational process:

The metaverse provides access to a highly immersive learning environment that enhances emotion, motivation, and the visibility of interaction. Khan, Lee, and Park (2024) emphasize that the intended use of the metaverse is linked to a perception of innovation; however, Gamma and Singh (2024) warn that the lack of adaptive data can turn it into a superficial experience disconnected from learning.

In contrast, adaptive systems focus on pedagogical personalization by leveraging information to dynamically modify challenges and provide feedback. Such systems have been shown to improve educational efficiency while promoting learner autonomy (Du Plooy et al., 2024; Rincón-Flores, E. G., 2024), making them a powerful tool for academic improvement.

Conclusions

In this work, we develop an integrative model that incorporates two technological innovations—the metaverse and adaptive learning—framed within pedagogical, ethical, and institutional lenses. We summarize key findings, educational implications, challenges, avenues for future research, and critical recommendations.

Evidence demonstrates a strong willingness to adopt the metaverse among university students ($\beta = 0.72$, $p < .01$). Furthermore, students with disabilities reported improvements in accessibility and empowerment (Maghaydah et al.,

2024). However, the immersive experience does not guarantee academic impact unless it is supported by relevant instructional design (Zhang et al., 2024).

Adaptive systems resulted in an 18% increase in academic performance, which correlated significantly with self-directed learning ($\rho = 0.68$, $p < .05$). Furthermore, a systematic review showed that 86% of studies reported improvements in performance and engagement (Du Plooy et al., 2024). However, the lack of data interpretation by instructors jeopardizes pedagogical effectiveness (Chen et al., 2025), reaffirming that automation does not replace thoughtful instructional design.

By merging both technologies, the model fosters an immersive and adaptive experience: metaverse environments increase motivation and equity, while adaptive systems ensure personalization and measurable results. Teacher training in critical digital skills, institutional infrastructure, and equity policies are key factors (Misirlis & Nikolaidis, 2023; Maghaydah et al., 2024).

The metaverse should only be used for experiential tasks such as simulations, immersive debates, or virtual laboratories, not for baseless spectacles (Khan et al., 2024).

Adaptive systems should enhance teacher reflection: algorithms provide data that teachers translate into methodological change.

Teachers' digital skills should include the ability to analyze learning data and design immersive environments, foster community, and evaluate impact.

Integrated technical infrastructure is needed: metaverse platforms, connectivity, accessible hardware, and adaptive environments.

Institutional policies must safeguard inclusivity and responsible data governance, especially regarding the use of data in immersive environments (Factors Affecting Metaverse Adoption, 2023). Universities must provide continuous development of learning plans with mentors, formative assessment, and communities of practice.

The metaverse is an advantage for students with disabilities because of its immersive capabilities, but, as Maghaydah et al. (2024) mention, it could deepen technological inequalities if access is not guaranteed for all.

The privacy of metadata in immersive environments and its traceability still lack specific legislation. There are risks that personal information will be stored resonantly and exposed without informed consent (Factors affecting the

adoption of the metaverse, 2023). Metaverses and adaptive learning systems require a deep mastery of techno-pedagogical skills that transcend mere technological infrastructure. Qiu, Isusi-Fagoaga, and García-Aracil (2023) find that many teachers lack adequate training to design immersive experiences with pedagogical objectives, which limits their ability to integrate the metaverse into academic contexts. In turn, these systems are so adaptive that they generate massive amounts of data, making it necessary to ensure data protection, responsible interpretation criteria, and transparency in the use of algorithms.

Chen, Martinez, and Singh (2025) also warn that without teacher support and interpretation, the use of adaptive systems can reduce learning to a simple mechanical interaction without reflection or pedagogical contextualization. A recent bibliometric analysis confirms that with the technological acceleration caused by the pandemic, there has been a shift of teachers to a strictly technical role that strips them of their function as educational mediators and impoverishes the critique of teaching (Strielkowski et al., 2024).

In order to reverse this trend, such training must begin with basic practice. Skills such as comprehensive reading, data interpretation, grounded immersive design, critical analysis, and adaptation of rhythms and activities must be provided. Only then can the available technical potential be integrated with truly deep learning.

In this sense, although universities in advanced contexts have VR and high-speed networks, these conditions do not exist in rural or less developed areas to deploy the metaverse. Maghaydah et al. (2024) point out that the metaverse is only accessible where powerful hardware and stable bandwidth exist, which excludes those who most need attention for their digital inclusion.

In contrast, adaptive systems that operate on low-power mobile devices have an obvious advantage in environments with limited connectivity because they provide sustainable functionality without the need for advanced infrastructure. Initiatives such as Edu-Metaverse are working on lightweight versions that would operate through browsers or mobile devices, although these efforts are still in the early stages.

However, to ensure equitable access, it is crucial to address the lack of investment in technological infrastructure or solutions that use more widely available technologies to avoid widening the digital divide. Many pilot projects demonstrate effectiveness in small-scale environments, but immersing 2,000 students in the metaverse experience poses highly complex challenges. While Rincón-Flores (2024) and other platforms offer promising solutions, there is a lack of interoperability between systems, legal restrictions, insufficient technical

support, and maintenance issues. In Australia, only 35 percent of teachers felt equipped to adapt their practice to large-scale metaverse formats without institutional guidance or collaborative support (Khan, Lee, & Park, 2024).

The situation is similar in adaptive systems. Their replicability depends on their integration with LMS platforms and their alignment with the current curriculum. The cost of these licenses, coupled with a lack of support and data analysis, along with cultural factors such as resistance to change and the absence of comparative data, limit their widespread adoption. Only those programs that incorporate mentors and collaborative teaching communities have demonstrated sustainable results over extended cycles (Maghaydah et al., 2024; Gamma & Singh, 2024).

The vast majority of studies on the metaverse and adaptive learning focus on periods of less than a year in terms of motivation and performance. It is clear that there is insufficient research analyzing these long-term effects, nor their impact on information retention, professional development, or the attainment of official accreditations. Panda, Arora, and Ghoshal (2024) emphasize this problem and call for studies that consider long-term changes.

In addition to this, although it has been documented that adaptive systems produce improvements of between 15 and 18%, it is unclear whether these results are sustained in subsequent courses, or what impact they have on the development of metacognitive skills or sustained self-regulation. The lack of longitudinal evidence makes it difficult to justify institutional investment and the design of public policies with solid foundations.

One area of research that has been neglected is the absence of longitudinal follow-up on the use of the metaverse or adaptive learning in university cohorts. It is necessary to analyze whether the positive effects on academic performance, self-management, and motivation constitute sustained benefits over a couple of years of regular use. Borenstein and Howard (2024) argue that it is necessary to analyze the impact that new technologies have on confidence and deep learning over time. At the same time, Panda, Arora, and Ghoshal (2024) state that these deficiencies in structural longitudinal evidence limit the validation of pedagogical effectiveness at the institutional level. Therefore, future research proposals should include longitudinal designs with indicators of performance, retention, critical competencies, and educational equity.

The next step is to move toward hybrid prototypes with adaptive capabilities built into metaverse environments where content is dynamically modified based on learner actions or reactions. Xu and Chen (2024) propose an integrative approach that combines VR/AR with AI systems that monitor interactions and

automatically adjust pedagogical parameters. Through their review of adaptive platforms, Malone and Ferrari (2024) reaffirm the notion that immersion, when combined with sophisticated algorithms, serves not only to enhance motivation but also to facilitate differentiated learning.

In this regard, researchers need to investigate hybrid frameworks with algorithms that respond to the user experience enhanced by immersion, as well as metrics of engagement, progress, and difficulty.

Tracking users in immersive environments creates new privacy and ethical challenges. Salsbury and Nguyen (2024) caution that uses of VR metadata may infringe on individual rights without automated systems for informed consent and algorithmic transparency. Borenstein and Howard (2024) argue that ethical metaverse design requires robust regulatory frameworks that ensure data equity, institutional accountability, and privacy management. These concerns give rise to research related to ethical frameworks, automated privacy alerts, and real-time algorithmic audits.

As with all emerging technologies, their effectiveness depends on the instructor's skill integration strategy. Rosa and Estrada (2025) demonstrate that AI-mediated communities of practice improve teacher training by enabling pedagogical co-design and collaborative reflection. It would be useful to evaluate training models that incorporate immersive mentors and peer feedback combined with adaptive feedback, focusing on their effects on techno-pedagogical skills, critical reflection, and overall competence.

The technological gap requires a comparative analysis between Europe, Latin America, Africa, and Asia. Maghaydah et al. (2024) point out that cultural, economic, and infrastructure challenges limit access to and effectiveness of the metaverse in peripheral regions. Therefore, it is necessary to study the contextual limitations (language, connection, training) for these technological models and their contextualized adoption. It is necessary to design socioculturally adjusted prototypes, evaluate their acceptance, and study their impact on equity and learning from a decolonial perspective.

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Sustainable bioeconomy and territorial development

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Introduction

In a world marked by unprecedented environmental impacts, the convergence of knowledge and the adoption of integrative strategies have become fundamental axes for responding to the dynamics of global change. The sustainable bioeconomy is emerging as a transformative proposal, aimed at replacing traditional models based on the intensive exploitation of resources with regenerative systems that prioritize the rational and responsible use of biological raw materials. This approach repositions territorial development as a multidimensional process that, beyond mere economic expansion, integrates criteria of social equity, technological innovation, and environmental conservation, which is essential for building resilient societies adapted to contemporary challenges.

The environmental crisis, evidenced by the degradation of ecosystems, the accelerated loss of biodiversity, and the worsening of climate change, underscores the urgent need to rethink our methods of production and consumption. Against this backdrop, the bioeconomy presents itself as a viable alternative by promoting a growth model based on the circular economy, in which waste becomes a resource and the use of biomass is managed sustainably. This transformation involves not only a review of production processes, but also

a profound restructuring of public policies and regulatory frameworks that have historically favored extractive and linear systems.

The research question, "How can the integration of sustainable bioeconomy strategies transform territorial development by generating synergies between economic growth, social equity, and environmental preservation?", lies at the heart of this debate. The question invites us to challenge conventional notions of progress and land management, proposing an approach that articulates scientific knowledge, technological innovation, and the active participation of local actors. In this sense, this study seeks not only to identify the barriers and opportunities inherent in the transition to bioeconomic models, but also to establish the theoretical foundations that justify and guide this transformation.

The central objective of this research is to propose an integrative framework that allows for the transformation of territorial development models through sustainable bioeconomy. The aim is to demonstrate that the incorporation of clean technologies, the adoption of circular economy practices, and the promotion of participatory governance can converge to produce more competitive, equitable, and environmentally friendly territories. To this end, this study draws on the analysis of high-impact scientific literature, including numerous studies and experiences documented in specialized databases, which demonstrate the transformative potential of the bioeconomy in various contexts.

From this perspective, the importance of rethinking development strategies from a systemic approach, in which public policies are aligned with the objectives of sustainability and equity, is emphasized. The integration of knowledge from areas such as biotechnology, environmental engineering, and social sciences is crucial for developing territorial models that are capable of harmonizing economic progress with the regeneration of ecosystems. This process also involves the implementation of flexible regulatory frameworks and the creation of incentives that facilitate the adoption of new technologies and the transfer of knowledge, both locally and globally.

In short, the sustainable bioeconomy is emerging as a paradigm of change that invites us to transcend the limits of the traditional development model, proposing resilient and adaptive territories that respond proactively to the environmental and social challenges of the 21st century. This research aims to lay the foundations for a new era of inclusive policies and clean technologies, in which innovation and equity are the fundamental pillars for building a sustainable future.

To explore the issues and transformative potential of the bioeconomy in territorial development in greater depth, the content is structured around three fundamental sub-themes:

Sustainable Bioeconomy in the Context of Territorial Development

Sustainable bioeconomy is defined as the set of economic activities that use renewable biological resources efficiently and responsibly, aimed at generating high value-added goods and services, while preserving ecosystems and promoting social equity (Bugge et al., 2016). This approach moves away from linear production models, which are based on intensive extraction and waste generation, to incorporate circular and regenerative strategies (Aguilar et al., 2020).

In the context of territorial development, the bioeconomy is presented as a strategic tool that allows for:

· Diversifying the production matrix: The implementation of production processes based on biological resources drives diversification that reduces dependence on traditional and fossil fuel sectors.

· Generating quality employment: The commitment to green technologies and circular economy processes favors the creation of sustainable jobs in emerging sectors.

· Promote environmental resilience: The regeneration of ecosystems and the efficient use of biological inputs contribute to mitigating climate change and protecting biodiversity.

This sub-theme is based on sustainable development theories and circular economy models, which have been extensively studied and validated in high-impact research. The scientific literature highlights that the integration of bioeconomic strategies into territorial planning enables the implementation of coherent public policies capable of articulating technological and social advances for the benefit of the environment (Kolter et al., 2012).

In addition, theoretical frameworks that emphasize the multidimensional nature of sustainability have been identified. For example, models based on life cycle assessment and comprehensive indicators allow for the simultaneous measurement of the economic, social, and environmental impacts of interventions in the territory (Finston and Thompson, 2021). These theoretical approaches not only strengthen the justification of the bioeconomy as an engine of territorial development, but also guide research methodologies that allow for a holistic analysis of the complexity of these systems (Pellerin and Taylor, 2008).

Experiences of Integrating the Bioeconomy in Territories

The transition to sustainable models is reflected in various case studies that document the practical application of the bioeconomy in territorial contexts in both Europe and Latin America (Ollikainen, 2014). This sub-theme focuses on analyzing experiences that have demonstrated the transformative potential of the bioeconomy through three fundamental axes:

Technological Innovation and Circular Economy

In specialized territories, the integration of clean technologies and the adoption of circular economy processes have made it possible to use waste and by-products to generate bioproducts and renewable energy. For example, the bioconversion of agricultural waste into biofuels and bioplastics has established itself as an effective method for closing production cycles and reducing pollution (Chong et al., 2022). Studies published in indexed scientific databases show that, in regions where these technologies have been implemented, there is greater economic competitiveness and a reduction in the environmental footprint (McCormick and Kautto 2013).

Synergies between innovation and the bioeconomy make it possible to boost emerging sectors, support industrial diversification, and promote new models of local entrepreneurship. In addition, the development of technology clusters and bioparks promotes technology transfer and capacity building in research and development (R&D), contributing to the creation of knowledge ecosystems that integrate academia, industry, and local governments (Coenen et al., 2015).

Community Participation and Territorial Governance

A crucial element in the adoption of a sustainable bioeconomy is the consolidation of governance models that include local and community actors. Citizen participation in decision-making promotes transparency and favors the implementation of solutions that are adapted to the specific realities of each territory. Several success stories have demonstrated the effectiveness of participatory structures, which combine local experiences and traditional knowledge with technological innovations.

Decentralized governance processes allow decisions to be made not only by government agencies, but also by various actors, from small businesses and cooperatives to community organizations, for the formulation of integrated strategies. The literature highlights how these collaborative approaches strengthen the resilience of the territory by facilitating the identification of local needs and the implementation of projects that generate shared benefits, both economically and socially.

Experience in highly vulnerable territories, in Latin American countries for example, shows that promoting social participation is crucial to overcoming the cultural and structural barriers inherited from exclusionary development models (Castagnola & Castagnola, 2021). Thus, the bioeconomy acts as a catalyst for change by promoting empowerment processes and generating greater cohesion between communities and the public sphere.

Public Policies and Regulatory Frameworks

The effective implementation of a sustainable bioeconomy within territorial development also requires an update of regulatory frameworks and a reformulation of public policies. Many of the current regulatory systems are designed to support extractive and linear models, which hinders the transition to strategies based on the circular economy and ecological innovation (Von Braun, 2018).

Experts agree on the need to create tax incentives, finance R&D projects, and promote public-private partnerships that facilitate this paradigm shift. The adoption of flexible regulations and economic incentives may become the key to consolidating infrastructures that support the development of green technologies and knowledge transfer. In this regard, the integration of the bioeconomy into the strategic plans of local and regional administrations favors the articulation of long-term policies that respond adaptively to market fluctuations and environmental challenges (Wield, 2013).

Experiences in European countries have shown that coordination between different levels of government and the implementation of training programs for the private sector create a favorable climate for innovation. The creation of innovation ecosystems—such as technology hubs and collaborative research centers—enables the transformation of traditional productive sectors and opens new avenues for sustainable territorial development, based on environmental conservation and social equity (Lim et al., 2022).

The analysis carried out throughout this article shows that the sustainable bioeconomy offers an integrative approach to addressing the complexity of current challenges in territorial development. It concludes that:

Rethinking Paradigms: Integrating the bioeconomy into territorial strategy makes it possible to replace traditional economic models—based on intensive resource exploitation and high volumes of waste—with circular and regenerative systems. This paradigm shift is supported by robust theories that consider the interrelationship between economic growth, environmental preservation, and social cohesion.

Importance of Innovation and Community Participation: The adoption of clean technologies and innovative processes, coupled with active community participation in decision-making, is fundamental to transforming territories. The success stories analyzed demonstrate that productive diversification and the integration of traditional knowledge with technological advances can generate positive synergies that boost regional competitiveness and promote social well-being.

Challenges in Policy Formulation: Updating regulatory frameworks and implementing adaptive public policies are essential to overcoming the structural barriers inherited from extractive development models. The creation of intersectoral alliances and the establishment of economic and regulatory incentives are essential measures to facilitate the consolidation of the bioeconomy and its integration into the territorial development agenda.

In summary, the empirical and theoretical evidence presented consolidates the view that the sustainable bioeconomy is not only a potential driver of innovation and economic diversification, but also an indispensable tool for achieving more resilient, inclusive, and environmentally friendly territories. The future of territorial development necessarily involves the transformation of traditional production systems into models that integrate criteria of sustainability, equity, and efficiency.

The continuity of this line of research invites further longitudinal studies that allow for a comprehensive evaluation of the impacts of bioeconomic strategies at various territorial scales. It is imperative to promote interdisciplinary dialogue and cooperation between academic, business, and government actors to consolidate governance systems that facilitate the transition to a circular and regenerative economy (Staffas et al., 2013).

This article is therefore a call to action to rethink current development models and to commit to a future in which the bioeconomy is the cornerstone of transformative processes in the territories. This will lay the foundations for generating a lasting impact on the formulation of public policies, the strengthening of technological innovation and, above all, the construction of more equitable societies in harmony with the environment.

The integration of the bioeconomy into territorial strategies should be geared towards the creation of interdisciplinary frameworks for analysis and action, including the simultaneous monitoring of environmental, economic, and social indicators. The search for solutions involving open innovation, technology transfer, and the active involvement of local communities will continue to open new paths for sustainable development in complex and diverse territories

(González et al., 2023). In addition, the consolidation of international alliances and transdisciplinary collaborations will ensure that the knowledge generated is not limited to theoretical studies, but is translated into practical and adaptive applications in the face of the challenges of a constantly changing world (Sasson and Malpica, 2018).

Bibliometric analysis is a fundamental tool for evaluating scientific output on a specific topic, providing information on research trends, academic impact, and collaboration between researchers and institutions. Its purpose is to identify patterns in the generation and dissemination of knowledge, which allows for an understanding of the evolution and direction of a field of study (Pülzl et al., 2014).

In the context of the bioeconomy and territorial development, bibliometric analysis helps to:

· Determine the growth of academic interest in the bioeconomy as a model of sustainable development and its influence in different regions.

· Identify the most influential authors and research groups in the area, as well as collaboration networks between universities and innovation centers.

· Analyze thematic trends, including the transition to biomass-based economies, regional development policies, and natural resource valorization strategies.

· Evaluate the impact of research on public policy formulation and the design of sustainable economic strategies.

· Detect knowledge gaps, which can guide future research toward less explored aspects of the link between bioeconomy and territorial development.

Sources and methodology of the bibliometric analysis

For the bibliometric study on bioeconomy and territorial development, a structured methodology was followed with the following elements:

1. Databases used

Scopus, one of the most recognized scientific databases, was selected for its broad coverage of academic articles and its ability to analyze impact metrics, citations, and collaboration networks.

2. Period analyzed and document selection criteria

Time range: Publications from the last 10 years were considered to identify recent trends in the field.

4. Selection criteria:

Articles from peer-reviewed scientific journals.

Studies that address the bioeconomy from a territorial perspective, including its impact on economic development and sustainability.

Publications with bibliometric relevance, i.e., those with a significant number of citations within the academic community.

Documents in English and Spanish to cover a global and regional perspective.

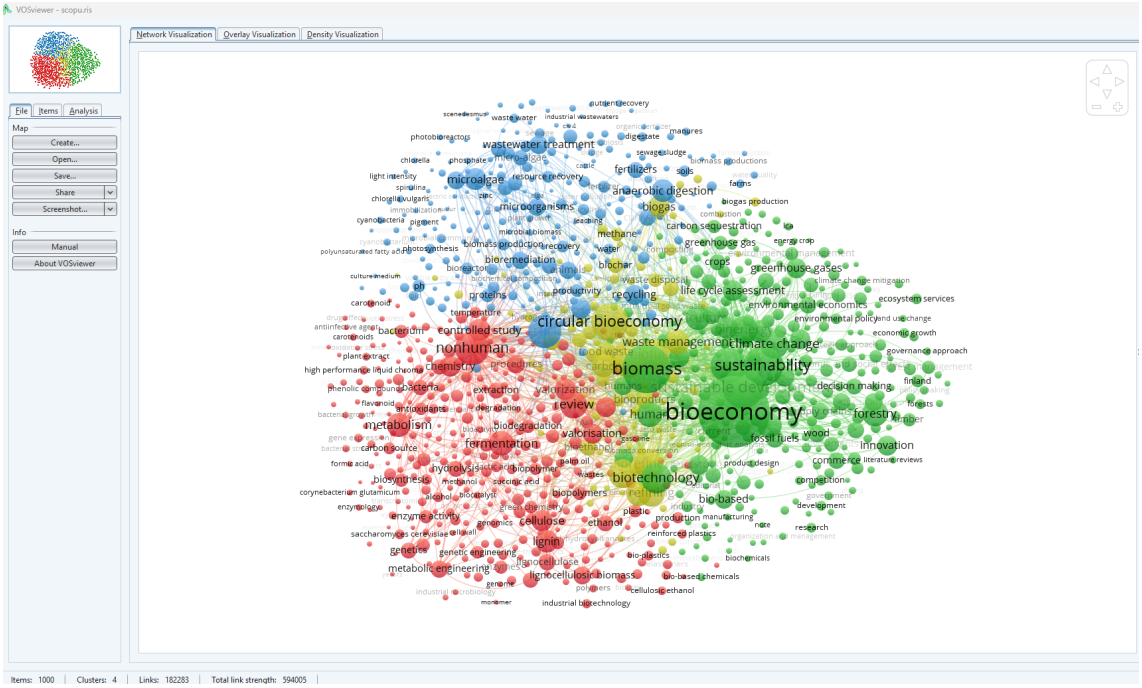
5. Keywords used: A search strategy based on key terms such as "sustainable bioeconomy," "territorial development," "innovation in bioeconomy," and "bioeconomy policies" was applied.

Citation analysis and impact metrics: Identification of the most cited articles and their influence in the field.

Co-authorship maps: Study of collaboration networks between researchers and institutions.

Thematic trends: Evaluation of the evolution of topics over time through the analysis of the most recurrent keywords.

Figure 1. Co-occurrence analysis of keywords by bioeconomy



Note. Obtained from VOSviewer

Conclusion

This work is based on the analysis of bibliometric data from 833 scientific articles in the Scopus database between 2004 and 2025. Co-occurrence network map analysis methods were used in the bibliometric software VOSviewer to identify characteristics.

The bibliometric study conducted on the bioeconomy and territorial development has identified key trends in research, the main actors in the field, and the evolution of knowledge. Research on the bioeconomy has experienced sustained growth over the last decade, reflected in the increase in scientific publications. This interest is due to the need to generate sustainable economic models that promote territorial development and reduce dependence on fossil fuels.

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How university students learn: keys to meaningful teaching

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Introduction

Understanding how university students learn has become a central challenge for higher education institutions. Today's social, technological, and labor demands call for an education that is not only comprehensive but also critical and autonomous (Bazán-Perkins and Santibañez-Salgado, 2025). Faced with this pressure, teachers are confronted with a fundamental question: How do university students learn today, and what elements should teachers consider in order to achieve truly meaningful teaching?

Zang (2025) has argued that teaching is not limited to transferring data; it involves activating pedagogical tactics that address the cognitive, the emotional, and what happens outside the classroom. This paper, therefore, aims to study these knowledge pathways and identify the inputs that teachers must manage to give meaning to each educational encounter.

This chapter contributes to the science of education by examining both the theory and practice of university learning. It focuses on how teachers' methodological decisions influence the way students organize and redraw the knowledge they have acquired. Recent studies, together with observations taken in the classroom, have begun to accumulate a remarkable set of findings. One stands out: centering the experience on the student seems indispensable if we want to cultivate their motivation, critical thinking, and ability to self-regulate and collaborate with peers. Incorporating the daily narrative scheme into teaching practice not only accelerates the movement of a class; it also strengthens in students and teachers that sense of belonging that pushes them to take the outside world seriously when they graduate.

The chapter is organized into five themes. It begins with a review of active learning and meaningful teaching; it is clear that genuine understanding only comes when students themselves take charge of the process. Next is the methodological itinerary: an outline of the qualitative approach and the tools used to collect and compile the information. Immediately after comes the empirical evidence, arranged in categories that allow us to hear, almost one by one, from students and teachers.

This is followed by a dialogue between these data and the literature consulted, noting both similarities and points of friction. The chapter closes with conclusions, the answer to the initial question, and some clues that could bring university teaching a little closer to real life.

University learning is enriched by innovative pedagogical practices and active student-centered methodologies. According to Grupo Compás (2023a), the development of professional skills in university settings depends largely on the articulation between theory and practice in an environment of critical collaboration. This perspective is reinforced by their analysis of reflective teaching, where they point out that pedagogical action makes sense when the teacher conceives of themselves as a researcher of their own practice (Grupo Compás, 2023b).

Likewise, the importance of teacher support and empathy in the classroom has been highlighted in recent literature. For example, Grupo Compás (2023c) argues that student engagement increases when teaching strategies appeal to the student's personal context, reinforcing their autonomy and intrinsic motivation. This vision is complemented by the approach to educational innovation developed by the same group (Grupo Compás, 2023d), which proposes that planning based on everyday experience promotes meaningful learning.

The inclusion of agile methodologies, reflective practices, and curriculum designs focused on active student participation, such as those systematized by Grupo Compás (2023e, 2023f), make it possible to overcome traditional barriers in university education. Finally, formative assessment as a feedback tool continues to be a key strategy, as also proposed in their methodological review for hybrid environments (Grupo Compás, 2023g).

Student learning and meaningful teaching

Student learning remains the ultimate goal of all teaching strategies; it is the visible sign that a formative approach has succeeded in getting students to internalize, reformulate, and reuse knowledge. In the university setting, this vision is not limited to storing information, but focuses on consolidating

competencies, activating critical thinking, and rehearsing skills that equip graduates for the challenges of professional life and civic engagement (Hernández-Ramírez et al., 2025).

From a theoretical perspective, learning has been studied under several seemingly incompatible models. For Skinner and Watson's behaviorism, the educational experience translates into a visible change in behavior in response to external stimuli. Beyond the observable, Bruner and Gagné's cognitivism describes the same phenomenon as a series of mental operations of encoding, storage, and retrieval. In parallel, constructivism posits that the subject constructs knowledge at every moment, supported by past memories and mediated by the social world around them; this position has been defended by Piaget, Vygotsky, and Ausubel, among others (Alhebaishi et al., 2025).

The constructivist approach includes, among other proposals, the famous theory of meaningful learning formulated by David Ausubel. Ausubel argued that a newly presented concept can only be assimilated in a lasting way if it is substantially and not merely randomly intertwined with what the student already knows. From this perspective, the content presented in the classroom acquires true cognitive effectiveness when the learner is able to incorporate it into their mental structure and give that information practical meaning (Brycen et al., 2024).

The quality of a university program is revealed when graduates can take the concepts they have learned to the office, unravel a complex case, and test the strength of their own solution. In courses designed in this way, grades can rise, and at the same time, young people end up thinking for themselves, making decisions autonomously, and looking at the social impact of what they do. Achieving this pedagogical horizon requires much more than a standard syllabus; it requires a didactic framework carefully anchored in reality and focused, without distractions, on what the learner experiences and does (Bryce et al., 2024).

Ng and his collaborators (2023) characterize teaching as a set of tactics, procedures, and materials that the teacher deploys to clear spaces in which learning can emerge. In this construction, the teacher renounces the role of mere narrator and becomes a mediator, guide, and facilitator of cognitive encounter.

A meaningful practice places the student at the center of the experience and, from there, stimulates their critical thinking, encourages their autonomy, and adapts the content to real-life scenarios that are relevant to them. To achieve this, teachers must carefully consider the characteristics, interests, and styles of the group so that they can design activities that respond to what those students

consider valuable. In this way, teaching not only fosters deep learning but also enriches theory with experience and, ultimately, prepares young people to face academic, work, and social challenges with genuine commitment.

A disturbing phenomenon that undermines the quality of learning has been documented at a university in Arequipa: the limited implementation of strategies that promote truly meaningful teaching. Although the faculty has solid training in their field, they continue to use conventional methodologies that prioritize frontal teaching, which is rarely tailored to the specific styles, interests, and realities of the students.

A frequent methodological limitation leaves students on the sidelines of their own learning process, and this, although they rarely say so out loud, translates into poor understanding of the material, little interaction in class, and difficulties in applying what they have learned. In many classrooms, the lack of strategies that encourage reflection, independent action, and real learning not only erodes grades but also slows the development of the skills that graduates will need early Monday morning in their first office meeting. This situation requires a fundamental review of the teacher's role, the student's view of the teacher, and the teaching strategies that end up occupying class time.

Based on the above, the following research question arises: *How do university students learn today, and what elements should teachers consider in order to achieve truly meaningful teaching?*

Methodological process followed

The study takes a qualitative approach, guided by phenomenological design, with the aim of deciphering the experiences and interpretations that students and teachers bring to the daily act of teaching and learning. In seeking to capture the meaning that meaningful pedagogy acquires in practice, the researcher avoids numbers and focuses on stories that speak for themselves. The case study modality was adopted at a university in Arequipa where, based on preliminary observation, teaching activities that promote deep learning appear to be limited.

The selection of informants was intentional and non-probabilistic, involving 10 advanced-level students, chosen for the critical maturity that years of classroom experience affords, and five teachers with substantial experience in higher education. This approach allowed for an in-depth exploration of the intersecting perspectives of those who teach and those who learn.

Two fundamental techniques of this approach were used to collect information: in-depth interviews and direct observation. Initially, the interviews allowed us to

gather the opinions, experiences, and subjective perceptions of the participants. Meanwhile, direct observation facilitated the recording of the actual dynamics developed in the classroom. The information obtained was analyzed using Atlas.ti software, allowing for the systematic organization, coding, and triangulation of the information. The qualitative analysis was carried out in four stages: first, units of meaning were identified within the material; then each fragment was given an open code; subsequently, the information was grouped into thematic categories; finally, common and discrepant patterns between behavioral and discourse data were examined. This procedure provided a holistic reading of the phenomenon in question and revealed, among other results, the constraints, enabling contexts, and windows of opportunity that can strengthen meaningful teaching at the university.

Perspectives on University Learning

Open interviews and in-situ observations in the classroom have shown that, in today's university, the act of learning depends on a constant tug-of-war: the student's curiosity, the immediate usefulness of the subject, and the design that the professor has decided to implement. The voices recognized in the fieldwork described a broken and fragmented educational journey; one session may be participatory and the next, pure routine.

One student made this statement: "I learn more when the professor approaches theory with real examples because that boldness forces me to think, not memorize." That need for empirical anchoring resonates, incidentally, throughout the literature on active learning. A classmate, in the same survey, attested to the opposite*: Sometimes I walk into the classroom, write down what's on the PowerPoint in my notebook, and then have no idea how to use* it. Such a disconnect, by its very nature, proves that a simple projection of data rarely translates into understanding that lasts more than a few days.

Teaching perspective

The teachers interviewed opened the dialogue by pointing out that the traditional lecture style is beginning to feel out of place in front of students who are drawn to screens and debates the moment the bell rings. In that same round of talks, one academic summed it up: listening is no longer enough; people need to touch, discuss, and sometimes even make mistakes in order to really learn.

One instructor summarized the moment: Students no longer learn just by listening; they need to experiment, participate, and debate. The same group, however, cited specific limitations: the lack of time to redesign a unit, the administrative burden that plagues them each week, and the tyrannical pressure to complete the program. Despite these obstacles, most were willing to include

more participatory techniques and valued technology, from a simple virtual classroom to online simulations, as a credible shortcut to sparking student motivation. Curiously, these preliminary impressions aligned with what observers noted in the field: the faculty urgently needs more opportunities for ongoing and accessible pedagogical training.

In-person observations recorded that in several sessions, the teacher limited himself to lecturing while the students remained silent, a pattern that often led to mental distraction and low personal involvement. In contrast, the parts of the course that encouraged debate, case analysis, or brief shared workshops showed an immediate and palpable uptick in collective attention. To verify these impressions, the field data was cross-referenced with interviews with the teachers themselves; most spontaneously confessed to the opaque resistance of the usual patterns: "*We often say that we need to innovate, but the semester clock and the curriculum are pressing us.*" This scenario occupies a central place in current literature on active pedagogy: only a teacher who sees themselves as a flexible mediator—able to adapt techniques to the texture of the group—and who challenges their own ingrained shortcuts can produce truly meaningful learning.

Emerging categories

Two categories emerged from the analysis: student learning and meaningful teaching. In the first, it was evident that autonomy, time management, and decision-making by the learner were associated with a deeper and more lasting understanding of the content. The link between theory and practice was almost unanimously seen as a non-negotiable condition for university knowledge to have real effects. When classroom activities resonated with the passions and future plans of young people, intrinsic motivation simply took off.

In the second category, it points to the direct effect of active methodologies such as case studies, open debates, or group projects, which force each student to take on a leading role. Behind this practical scenario, the quality of the relationship that the teacher establishes with the classroom appears to be the real multiplier. Interaction based on empathy and genuine respect builds invisible bridges that make the group commit to much more than just the grade they will get. Finally, formative assessment appears, along with these ingredients, as the most accurate thermometer that can be offered to the class, as constant feedback allows learners themselves to read their progress curve and decide where to make visible adjustments.

The analysis of the discourse and routines that emerge within the four walls of the classroom revealed a point of agreement: both students and teachers place motivation at the core of learning. It makes sense; teaching truly takes root when a theoretical framework is tempered by practice and everyday conversation is

sustained by an atmosphere of mutual respect. However, recordings and field notes revealed two notable shortcomings in the current role of the teacher. Students ask for clear signals and visible support, while some teachers still cling to the old model of one-way communication, and this resistance slows down the full adoption of truly active strategies.

A systematic examination of classroom discourse and behavior revealed a common core: both students and teachers affirm that motivation is the foundation of learning. Both groups maintain that teaching takes root when theory is grounded in concrete practice and a climate of respect sustains the conversation. Even so, the same study showed notable damage to the role of the teacher. Students demand continuous guidance and visible support, while certain teachers still cling to a traditional model where content flows in only one direction, and this resistance slows the full adoption of truly active strategies.

Triangulation with psychological currents of learning confirms the initial observations. Vygotsky, with his idea of social constructivism, points out that face-to-face conversations and ongoing teacher support are what truly drive cognitive development. This reading emphasizes what many already intuit: in the classroom, a sincere and empathetic bond is never a luxury; it is the driving force. On another note, Ausubel places the connection between new concepts and prior knowledge at the center of the process, which explains why students, almost in unison during interviews, call for a more decisive contextualization of theory in practice. Humanistic approaches, which advocate autonomy and the pursuit of self-actualization, are echoed in the value that these same young people place on the independent and motivated management of their own learning.

Recent findings suggest that university learning gets a big boost when theory is merged with real-life work situations and, above all, when students are actively involved in class. This research adds that the inner spark of students is not a secondary detail and needs to be at the center of the stage. Based on this observation, many teachers say they want to shift their sessions toward more interactive formulas, although the workload and pressure of the program always end up putting the brakes on. Amid this back-and-forth, meaningful teaching appears as a refuge where participatory strategies, empathy, and truly formative assessment can be found. This idea is not isolated; it converses with currents such as constructivism, learning that feels relevant, and the humanistic approach. Therefore, putting the student at the center still feels like a project that, if it moves forward, must nurture their autonomy, let their voice be heard, and contribute to their complete growth.

Dialogue between evidence and literature

This study reveals that university students really advance when they get their feet wet in the subject matter, when a distant theory suddenly encounters a real-world problem, and when their own curiosity is drawn to a challenge. Both first-year students and faculty veterans confirm that dynamic, contextual activities are a necessity, even though teachers continue to run into the endless wall of paperwork and reports. The authors, faithful to constructivist and humanist voices, insist that putting the student at the center requires creating spaces of freedom and opening doors where concrete knowledge can breathe.

The results of this research show that the classroom needs to be active, accessible, and, above all, student-centered, giving students a voice and the momentum they seek. In a recent study, Lervik et al. (2025) observed that stumbles—not simple mistakes—serve as beacons of reflection for nursing students in simulated training; the key moment comes when debriefing becomes critical dialogue. This observation coincides with what we have been proposing in the report: strengthening formative assessment and maintaining constant teacher support, necessary steps if we want learning to truly take root.

Michaud and McDonough (2025) reviewed task-based language teaching and quickly noticed that the moment when correction is offered, as well as the format chosen by the teacher, make the difference between fleeting progress and solid learning. The tangible gain is anchored in specific mental functions—working memory, cognitive skills—and not in a vague notion of motivation. Their conclusions fit with what we found in our own exploration: learners insist that varied approaches anchored in everyday situations are by far the most effective for them.

The research by Parejo and Cortón-Heras (2025) underscores the importance of learning outside the classroom, citing field trips to innovative educational centers where students actively participate and critically reflect on what they observe. According to the authors, the physical space and methodological design of the tour make a difference in how knowledge is constructed. The data show that many students feel completely alienated when classes are restricted to lectures.

Therefore, research agrees that university teaching requires a change of direction: more active, reflective classes that are located and tailored to each student's trajectory. This need aligns well with constructivism, the humanistic shift, and the ideas of meaningful learning that have marked the professional debate. At the same time, evidence continues to warn of the fragility of the institutional walls that still hold back this movement. That is why it is reiterated,

almost urgently, that the pedagogical training of teachers themselves must be reinforced so that they, in turn, place the student at the center of the process.

The evidence gathered in this study indicates that the depth of student learning increases significantly in settings where personal autonomy is complete. When students manage their time, choose research paths, and connect content to their own interests, understanding becomes more solid and lasting. This same thesis is supported by the work of Suzuki et al. (2025), which examines guidelines for physical pairing between peers in the field of medicine. Although the research is set in a clinical context, it underscores the importance of respecting each student's privacy and incorporating their individuality into the technical procedure. The consensus that emerges from both sources suggests that recognizing this personal space, combined with the control that students exercise over their educational trajectory, catalyzes both commitment and depth of understanding.

Mendoza and Yan (2025) reveal in their recent analysis that school practices can embody, almost materialize, the famous growth mindset. Those who adopt this perspective end up armed with more robust self-regulatory resources and the pragmatic courage to try, rectify, and refine a skill. This dance between self-discipline and relentless iteration ultimately fuels palpable student autonomy. A young person who is convinced that their intelligence is expandable begins to seek out challenges for themselves, endures the inevitable wear and tear of learning, and, in the story of their education, ends up being the main protagonist.

Morales and Cabezas (2025) explore the intrinsic motivation that arises when a student perceives that an activity has personal value. Their empirical work in foreign language classes shows that exercises anchored in individual goals increase both the willingness to participate and the desire to progress.

A similar pause appeared in our own data collection: informants developed remarkable levels of curiosity and dedication when the material was intertwined with their daily projects and routines. Ruos and colleagues (2025) show that teaching behavior alters the subjective value that students place on their work, and that change has a direct impact on their drive to learn.

The testimonies obtained in the present study coincide with this finding; students maintain that the relevance and usefulness of the content are the main sparks of their interest. When future professionals perceive that what they are studying is reflected in their routine and has a clear objective, the intensity of their participation usually increases significantly.

Research on meaningful learning in higher education highlights that students become truly engaged when they enjoy a certain degree of freedom, when they are convinced that they can progress, when new content connects with what they already know, and when that new information ultimately fits in with their personal projects. In this model, the teacher ceases to be a mere transmitter and becomes a guide who activates, sustains, and deepens individual motivation, group commitment, and lasting understanding.

The data collected in this study suggest that truly meaningful teaching rests on three pillars: first, the choice of active methodologies that engage students and turn them into participants; second, the construction of an empathetic bond that pushes students to strive; and third, a formative assessment system that provides constant feedback and adjusts the course of learning. Each of these facets has found or possesses both support and counterpoint in recent literature.

The recent study by Michaud and McDonough (2025) argues that meaningful activity, supported by specific tasks and adapted to the limitations of the student's working memory, enhances effective learning. Their conclusions resonate with what we have observed in the classroom: active methodologies, while stimulating participation, require careful adjustment to the pace and language skills of each student. Among the strategies we tested are case studies and collaborative work. Both formulas, in line with task design, encourage greater engagement and promote more lasting knowledge.

In terms of interpersonal bonding, research presented by Yi et al. (2025) emphasizes that an empathetic connection between teacher and student can blur the psychological walls that often separate the two, even in entrepreneurial education classrooms. Although the focus of the work is different, the central message—not that of empathy as a device to break down resistance, foster emotional inclusion, and ensure engagement—fits well with observations gathered in other university records. In fact, in our own notes, we have noted that bonds based on respect and emotional understanding tend to energize active participation and sustain student motivation in the long term.

With regard to formative assessment, the study by Tian et al. (2025) suggests that the quality of teacher feedback is intertwined with the closeness of interaction and the student's sense of belonging to the school, which in turn nurtures self-regulated learning. In our work, students emphasize how crucial it is to receive constant, personalized feedback; these notes, they say, allow them to rethink what they are doing and redesign their study habits. This perception fits with that of the authors cited: feedback is not measured only in cold data; it acquires emotional and motivational weight when it springs from an environment in which young people feel safe.

The study by Parejo and Cortón-Heras (2025) on visits to innovative educational centers is presented as an illustrative case of learning outside the conventional classroom space. By focusing on direct encounters with non-traditional school practices, the study highlights how genuine experiences rooted in the immediate context can revitalize university teaching, link theory with action, and strengthen both critical judgment and informed deliberation among students.

Despite their theoretical diversity, recent analyses agree on one central idea: truly transformative learning requires, above all, active participation, substantive human interaction, and effective feedback. In the same vein, the studies argue that quality university practice must be empathetic, dialogical, and oriented toward continuous improvement—postulates that are certainly aligned with the constructivist and humanist roots on which this work is anchored.

The discussion shows that meaningful teaching in the university setting is built on active methodologies that promote participation, empathetic relationships between teachers and students that strengthen commitment, and formative assessment processes focused on constant feedback. These practices not only improve learning but also enhance self-regulation, intrinsic motivation, and students' sense of belonging. However, challenges remain in the systematic implementation of these strategies, especially in contexts where traditional approaches or institutional limitations predominate. Therefore, it is necessary to continue to explore the topic in depth to identify contextual conditions and personal and organizational factors that favor or hinder student-centered teaching, with the aim of achieving sustained transformations in university educational practice.

Recent literature agrees that truly meaningful university teaching is based on active methodologies, that is, exercises, projects, and debates where students are no longer mere listeners. This dynamic, accompanied by an empathetic relationship between teacher and student and a formative assessment system that offers near real-time feedback, produces more lively classrooms with much more engaged students. This same combination also tends to increase self-regulation, a sense of belonging, and motivation that comes from within the student.

Even so, making the leap from discourse to daily routine faces multiple obstacles; in many faculties, the weight of traditional customs, lack of time, and some administrative restrictions continue to set the pace. Therefore, further research is needed to identify the contextual, personal, and organizational variables that hinder or obstruct student-centered pedagogy and university practices in order to bring about real and lasting change.

Conclusions

The research suggests that university students retain and understand material better when their role is no longer strictly passive. The habit of taking the initiative, choosing sources, and evaluating the time available seems to bear immediate fruit. Paradoxically, that same autonomy finds its maximum expression when students link the classroom subject with a personal project, a forgotten hobby, or the daily routine of public transportation. The interaction between theory and practice is therefore not merely a slogan, but the scaffolding that transforms an abstract concept into a usable tool within the parentheses of a semester. Of course, the spark that keeps that scaffolding standing is intrinsic motivation; without that fire, the bricks of content crumble before the class is over.

According to the findings for achieving meaningful teaching, the role of the teacher should not be based on the transmission of content, so it is essential to apply active methodologies such as active collaborative work, problem-based learning, or case studies, which encourage critical participation and the collective construction of knowledge. Similarly, the importance of a teacher-student relationship based on active listening, empathy, and mutual respect is highlighted. In addition to formative assessment as a fundamental resource that accompanies feedback and strengthens learning, these aspects definitely shape a student-centered educational model aimed at developing autonomy skills and transformative and comprehensive training.

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Audiovisual media: an effective strategy for promoting a tourism agency

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Introduction

According to Martinez et al. (2022), tourism is an activity that has proven to generate significant foreign exchange in all countries, promoting economic development in contexts where hotel services, gastronomic services, products, and tourist tours have been promoted (Lujan et al., 2023). In this sense, it is one of the most dynamic activities in companies seeking to invest in innovative ideas that contribute to promoting and disseminating the tourist resources of a locality (Pérez, 2017). For their part, Barros and Bores (2024) mention that complex thinking among entrepreneurs and new global trends have generated significant transformations in organizations, affecting social, economic, cultural, and environmental aspects.

A tourism agency is a company or entity dedicated to planning, organizing, and offering services related to tourism and travel (Mojica et al., 2021). These agencies act as intermediaries between travelers and tourism service providers,

such as airlines, hotels, cruise lines, car rental companies, among others (Coromoto and Morillo, 2016). Their main objective is to facilitate the travel experience of their customers by providing them with tour packages, accommodation reservations, airline tickets, recreational activities, transfers, and other travel-related services. In this sense, they can offer a wide variety of travel options, from leisure and family vacations to business trips, honeymoons, adventure excursions, cultural trips, and much more. In addition to organizing itineraries and booking services, travel agencies often provide advice and recommendations to travelers, helping them select destinations, activities, and accommodation options that suit their preferences and needs.

Audiovisual platforms are a powerful communication resource that integrates visual and auditory components to disseminate information effectively (Vilena, 2022). Used in various settings, from television and film to streaming services and social media, they have transformed the way content is consumed (Chávez, 2019). Thus, their ability to capture the viewer's attention and arouse emotions through moving images and sounds gives them a notable impact on society (Gómez, 2010). Furthermore, according to Quezada et al. (2022), technological advances have facilitated the creation of high-quality productions that are accessible to a global audience, so they not only entertain but also educate and inform, playing a vital role in shaping opinions and spreading culture (Vera et al., 2024).

Piura is a department located in northern Peru, and it has a range of tourist resources with the potential to offer diverse experiences and adventures to tourists. The region is made up of eight provinces, each with its own unique characteristics, as well as districts that contain resources and attractions for generating tourism-focused activities. A clear example is Canchaque (Silva et al., 2021), considered one of the most attractive districts for tourists and, therefore, receives continuous visits from school, university, and other delegations. It has one of the most attractive landscapes in the department of Piura, to the point of being considered the Switzerland of Piura.

It is important to understand that tourism is an activity that causes people to travel to different parts of the world with the intention of generating cultural exchange experiences (Aymara, 2019). In this sense, it is essential that all activities are planned and organized to ensure that tourists have a pleasant stay and feel safe in a place outside their context. Sandoval et al. (2019) and Velázquez et al. (2021) argue that tourism agencies play an essential role in coordinating a series of activities through itineraries that offer quality tourism products based on the natural, gastronomic, and cultural riches that the Piura region has to offer, providing visitors with absolute safety and guidance.

Creating a successful tourism agency requires the implementation of a comprehensive plan that incorporates audiovisual media strategies to stand out in a competitive market. In today's digital age, presence on visual platforms becomes crucial. In this sense, the agency could leverage social media and video platforms to create engaging content that highlights tourist destinations, unique experiences, and exclusive packages. The audiovisual strategy could include the creation of high-quality promotional videos (Araújo and Fraiz, 2017), highlighting the services and quality of the experience offered by the agency. In addition, the implementation of live broadcasts on platforms such as Instagram or YouTube would allow a direct connection with customers, giving them the opportunity to virtually explore destinations and receive answers in real time.

The creation of multimedia content is not only limited to promotion, but also to education. The agency can develop tutorials, guides, and informative blogs about tourist destinations, providing potential customers with valuable information and building trust in the brand. In addition, the use of virtual or augmented reality in audiovisual media could offer immersive experiences, allowing customers to have a more realistic preview of their future destinations. In terms of advertising, the agency could implement attractive advertising strategies on streaming platforms, television, and radio, maximizing brand visibility. Likewise, collaborating with influencers and content creators specializing in travel could also be an effective tactic to reach specific audiences and generate interest in the services offered by the agency.

Engaging content in audiovisual media is key to capturing and maintaining the attention of audiences in a digital environment saturated with information. This type of content must be dynamic, visually striking, and emotionally resonant, combining visual, audio, and narrative elements in a harmonious way (Borja, 2021). Videos with well-structured stories, relatable characters, and careful aesthetics generate a higher level of emotional connection, making it easier for the message to be remembered and shared (Sanagustin, 2020). In addition, interactivity and the ability to adapt to different platforms, such as social media or websites, increase their appeal by offering a more personalized and accessible experience.

Production quality is a determining factor in the success and perception of content by audiences. This quality is evaluated through various technical aspects, such as image resolution, sound, editing, production design, lighting, and art direction. Each of these elements contributes to creating an immersive and professional experience that directly influences the viewer's emotional reception. In the current context, where digital platforms offer a wide variety of content options, users tend to prefer high-quality audiovisual productions, associating them with greater credibility and value. According to Keane and

Moran (2008), improvements in technical quality, driven by advances in digital technology and production tools, have raised audience expectations, forcing creators to adopt higher standards to compete in a saturated market. Furthermore, careful production reflects not only an effort to capture the viewer's attention, but also a commitment to the narrative and the message conveyed, reinforcing the connection between the content and its audience.

Likewise, it has experienced significant growth in recent years, thanks to technological innovations and the adoption of new distribution platforms. A recent study highlights how the use of cloud-based technologies has enabled greater flexibility and efficiency in the production of high-quality audiovisual content, leading to optimized transmission over IP networks and the creation of real-time media. In addition, the use of artificial intelligence (AI) in production is revolutionizing the sector, enabling automation and advanced analytics that improve the quality of both visual and audio content and personalize the user experience. These advances combine to deliver more sophisticated audiovisual productions, with shorter delivery times and greater adaptability to different consumption platforms.

Audiovisual media distribution channels have evolved significantly with the advancement of technology, expanding the options for reaching global audiences. Traditionally, television and film were the main means of distribution, but with the advent of the Internet, platforms such as YouTube, Netflix, and social networks such as Instagram and TikTok have taken on a leading role. These channels allow for faster and more efficient dissemination, adapting to new forms of consumption, which tend toward short content that is accessible anytime, anywhere. According to Jenkins (2006), digital convergence has allowed consumers to be both receivers and distributors of content, which has democratized access to the media and expanded the reach of audiovisual productions. In addition, streaming services have facilitated audience segmentation, allowing creators to reach their target audiences more precisely. This has transformed dissemination into a more interactive and personalized process, where content can quickly go viral through social media, enhancing the impact of audiovisual media.

Audience segmentation is a key strategy for optimizing communication and effectively reaching specific groups of people, thereby improving the relevance of content. Instead of targeting a mass audience, audiovisual media creators and distributors analyze demographic, geographic, psychographic, and behavioral criteria to identify specific segments, such as age, gender, location, interests, and consumption habits. This practice has become more relevant with the proliferation of digital platforms such as YouTube, Netflix, and social media, which allow for more precise segmentation through algorithms that track user

preferences. According to Kotler and Armstrong (2018), segmentation allows brands to develop content that resonates with the values and needs of the audience, increasing the effectiveness of messages. Furthermore, in the context of audiovisual media, the personalization and adaptation of content to these segments not only enhances the user experience but also maximizes the return on advertising investment by ensuring that the content reaches those most likely to respond favorably.

This transdisciplinary study has been designed with the aim of offering a comprehensive overview of the audiovisual media-based communication strategies used by tourism agencies to strengthen their market positioning. It also seeks to identify which strategies are linked to specific methodological approaches and, conversely, which are applied across the board in the field of tourism marketing, regardless of the profile of the destination or the type of agency analyzed.

Theoretical and conceptual foundations of audiovisual media

Audiovisual media are intermediaries that contain elements of sound and image that can be seen and heard, facilitating the transmission of information, as they use moving images and sound to explain the material (Kurniawati et al., 2022). Tourism induced by audiovisual fiction responds to the shift and interest of new cultural consumers towards creative industries, new formats of tourism promotion, and new forms of audiovisual production derived from the emergence of increasingly demanding audiences (Puche-Ruiz et al., 2024). Currently, audiences are showing a growing tendency to explore and interact with services and destinations through the use of digital technologies and social networks, which amplify or even replace their consumption (Pinto, 2024). Given their impact on the tourist's decision-making process, it is essential to analyze the potential of audiovisual productions to build and project a distinctive image of a travel agency and the destinations it offers, as well as their ability to influence the perception that audiences develop about them (Nieto-Ferrando et al., 2021; Guo et al., 2025).

Audiovisual media for promoting a travel agency are creative and innovative strategies that simplify the purchasing process, with minimal effort and a touch of entertainment; viewers can easily purchase products or services thanks to videos designed for users to click on and buy directly (Banerjee et al., 2025). In this context, incorporating ICT to attract new customers is an essential strategy for understanding the specific market segment, strengthening business relationships, and boosting sales (Rodrigues et al., 2023). The audiovisual media system of a tourism company includes indicators such as sales promotion, price analysis and variations, the use of advertising to attract customers, revenue

growth forecasts, the study of customer needs, service planning, and the range of products offered (Velentza and Metaxas, 2023). A clear example is online travel agencies (OTAs) such as Booking.com and Expedia, platforms with advanced algorithms and intuitive interfaces that have innovated the process of planning and organizing trips by providing seamless booking experiences, personalized recommendations, and transparent pricing (Mehdi, 2025).

Tourism is a commercial industry and a promising economic sector, with varying importance depending on the country, depending on the tourist resources available and the financial, human, and technological resources allocated to prepare it for the future and turn it into a tourist destination (Chouari et al., 2024). For this reason, travel agencies are tourism intermediaries dedicated to the organization, promotion, and sale of travel, services, and tourist attractions. This tourism distribution chain serves to offer a wide range of tourism products and services tailored to customer needs and with high quality standards to ensure satisfaction (Bracho et al., 2024). In this sense, audiovisual strategies are essential for attracting tourists and increasing revenue in the travel and tourism sector. The use of technology, including websites, social media, mobile applications, and email marketing, has become increasingly important in promoting travel and tourism (Martins et al., 2025). Thus, today's tourist is an e-tourist, hyperconnected and overinformed. In this context, the use of digital marketing in travel and tourism agencies is considered the most stimulating and fastest-growing method (Sharma et al., 2024), given that digital transformation allows visitors to book restaurants, hotels, and tour packages and pay with their smartphones, eliminating the need for paper menus and cash transactions (Yadav, 2025). Marketing and communication are disciplines that reflect changes in society and technology, modifying the ways in which companies and consumers interact, from print advertisements in newspapers to television, transforming the link they have with their audience. Social media, in particular, has decentralized communication, empowering consumers as content creators (Bastidas and Sánchez, 2024).

Application of audiovisual communication in tourism

Audiovisual content related to the tourism sector is fertile ground for the dynamic construction of an identity. The audiovisual strategy contributes to the visibility of little-noticed elements and helps to generate an image that allows the inhabitants of a territory to value and enhance their own heritage, strengthening their identity (Hernández et al., 2024). The creation of the image of a tourist destination in the mind of a potential user through social media must consider two factors: the information and commercial messages coming from organizations and companies in the tourism sector, from a cognitive or emotional approach (Baraybar-Fernández et al., 2023). In this context, the impact of

audiovisual media (television, cinema, audiovisual content on the internet) is a significant influence because it occupies an important place in the cultural environment and the promotion of tourist destinations (Jedlowski, 2023). The use of social media is beneficial both in its organization and in its implementation and communication. It should be noted that social networks provide new opportunities to organize, disseminate, and communicate tourist events, achieve greater visibility, engagement, and participation, both physical and virtual (Campillo-Alhama and Martínez-Sala, 2019). The efficient use of collaborative platforms for travel companies, together with social media, will promote automated management, efficient promotion, greater social participation, and the generation of value for the destination. Consequently, it is essential to establish defined strategies that integrate audiovisual media for the promotion of a travel agency.

Critical conceptual review

The results presented reveal an extremely strong and positive correlation (Spearman's Rho = 0.981) between the use of audiovisual strategies and the promotion of a travel agency, suggesting a solid relationship between the two variables. When analyzing these results, it is clear that the use of audiovisual tools such as videos, promotional images, and multimedia content on digital platforms contributes significantly to the agency's recognition and reach, as it has important implications for the tourism industry and confirms that efficient implementation of these strategies not only broadens the spectrum of potential customers but also improves the agency's competitiveness in an increasingly digitized market (Morais et al., 2025). Furthermore, given the high level of significance, agencies can be confident that investing in audiovisual media is a sound strategic decision to improve their visibility and attract more tourists, which can ultimately translate into an increase in customers and loyalty.

The results obtained show a positive and significant relationship between attractive content and the dissemination of a tourism agency, which supports the research hypothesis. Spearman's Rho correlation coefficient (rs) = 0.880 indicates a considerable association between the two variables, suggesting that the more attractive the content produced by the agency, the greater its ability to reach and capture the attention of potential customers; playing a crucial role in brand differentiation and fostering customer loyalty (Lovrinčević et al., 2025). This finding has practical implications for the study by Barrera et al. (2022), as it underscores the importance of developing audiovisual and visual content that is not only informative, but also aesthetically appealing and emotionally impactful. In a highly competitive tourism market, where public attention is increasingly fragmented, the power of well-designed and visually appealing content becomes a key strategic tool for increasing an agency's visibility and reach.

The results shown confirm that audience segmentation has a strong and significant relationship with the dissemination of a tourism agency, which supports the research hypothesis. Spearman's Rho correlation coefficient (rs) = 0.712 reflects a considerable positive association between the two variables, suggesting that proper segmentation of the target audience significantly improves the agency's visibility and reach. This finding has relevant implications in the field of tourism marketing, as it underscores the importance of accurately identifying and defining different customer segments to optimize dissemination strategies (Kim et al., 2019). By segmenting the audience, the agency can personalize its message and content, thus achieving greater resonance among the groups of tourists most likely to consume its services. The observed correlation indicates that segmentation allows for a more efficient use of promotional resources, directing efforts towards specific niches and obtaining better results in terms of reach and conversion. In a context of increasing information saturation and diversity of tourist profiles, a tourism agency's ability to effectively target specific segments is crucial to maximizing its impact and strengthening its market presence.

With regard to the "dissemination channels" dimension and the dissemination of a tourism agency, there is a highly significant relationship, with a Spearman's Rho correlation coefficient (rs) = 0.885, reflecting a very strong association between the two variables. This result is consistent with the study by Rodríguez (2022), which argues that the diversity and relevance of the channels used to reach the target audience are crucial to maximizing the impact of tourism marketing strategies. This finding is also similar to the study by Almakayeel (2023), which emphasizes that digital marketing and social media play an important role in driving the travel business. In a context where consumers use multiple digital and traditional platforms to gather information and make travel decisions, an agency's ability to correctly select and manage these channels becomes a determining factor in its success (Prieto and Rodríguez, 2022). Distribution channels, such as social media, websites, travel blogs, influencers, and traditional media, not only facilitate access to a wider audience but also allow for more precise segmentation and more direct communication with potential customers. According to Koliouska and Andreopoulou (2023), these tools can be used to provide travelers with access to travel information, booking and reservation systems, virtual tours of destinations, personalized recommendations, and other travel-related services.

With regard to the quality of production and dissemination of the tourism agency, there is a significant relationship with a Spearman's Rho correlation coefficient (rs) = 0.759, indicating a considerably high association between the two variables. This finding, supported by a two-tailed significance value (Sig. =

0.000), lower than the levels of **α** = 0.01 and 0.05, allows us to accept the specific research hypothesis, confirming that production quality is strongly linked to a travel agency's ability to increase its visibility and reach, and is consistent with the findings of Nieto et al. (2024). Production quality, which encompasses aspects such as visual aesthetics, professional design, and well-structured content, plays a crucial role in public perception and, therefore, in the effectiveness of dissemination strategies (Chih-Hui et al., 2024). The results suggest that consumers, in this case potential tourists, respond more favorably to promotional campaigns that demonstrate a high standard of quality in their audiovisual execution. This is especially relevant in an increasingly digital environment, where competition for public attention is intense, and the quality of promotional materials can make the difference between the success and failure of a marketing campaign.

Conclusions

A travel agency plays a key role in the travel industry by acting as a bridge between travelers and tourism services. It offers convenience, expert advice, and tailor-made solutions so that people can enjoy unforgettable travel experiences. Whether planning a family vacation, a business trip, or an adventure getaway, travel agencies make planning and organizing trips more accessible and efficient, thus contributing to the growth and diversification of tourism worldwide.

Audiovisual media play a crucial role in the tourism industry, as they allow destinations to promote themselves in an attractive and effective way. Through videos, images, and sound, experiences and emotions can be conveyed that inspire potential travelers to visit new places. In addition, these media facilitate the dissemination of practical and cultural information, improving travel planning and the travel experience.

Among the results obtained, based on a sample of 384 people, it was found that 87% of respondents choose to hire the services of a travel agency every time they go on a trip, 50% choose to visit the beaches of Piura, 81% choose to purchase a tourist package, and 21% opt for provincial and regional transportation, followed by 17% who choose to make a hotel reservation, while 16% prefer a tourist package. Finally, 69% agreed that a travel agency with specialists knowledgeable about tourism is necessary to provide efficient service.

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Cultivating Solution-Seekers and Analytical Thinkers in the High School Classroom

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Introduction

Developing problem-solving and critical thinking skills in reading and writing is essential for EFL high school students, as it enhances their communication and prepares them for future academic and life challenges. However, many schools in Ecuador still use outdated teaching methods focused on memorization, limiting students' ability to think critically and solve problems. Additionally, issues like overcrowded classrooms and limited resources further hinder effective learning.

Several studies highlight the importance of adopting modern teaching strategies. For example, Alberida *et al.* (2022) found that problem-solving approaches help identify and support students with strong critical thinking skills, preparing them to face modern challenges. Wale and Bishaw (2020) showed that inquiry-based learning fosters critical thinking and problem-solving through active, hands-on experiences. Similarly, Cosgun and Atay (2021) demonstrated that project-based learning boosts both language proficiency and creative thinking. Finally, Cáceres *et al.* (2020) emphasized that Latin American teachers are increasingly integrating critical thinking into subject-specific lessons to help students become more independent and reflective thinkers.

Defining problem-solving

According to Fissore *et al.* (2020), problem solving is a cognitive process in which students actively engage in identifying, analyzing, and resolving complex, unfamiliar challenges. This process involves the use of cognitive strategies, collaboration, and reflection, and requires the application of critical thinking, reasoning, and creativity to define the problem and develop a solution plan. Likewise, Luna (2015) emphasized that problem-solving is a key skill for 21st-century learning, which includes identifying issues and assessing options. It requires a variety of abilities linked to creativity and critical thinking. While Morin *et al.* (2015) stated that problem-solving results from any teaching method and involves developing alternatives for complex issues with limited knowledge. Fostering problem-solving requires analysis, synthesis, and assessment, necessitating a balance of analytical and creative thinking. It is essential for high school

students to explore problems and solutions. Alberida *et al*. (2022) also mentioned that problem solving fosters argumentation and critical thinking skills, preparing students to evaluate facts and draw conclusions. This process enhances critical thinking, prompting students to ask questions and solve contemporary problems.

Defining critical thinking

Cosgun and Atay (2021) defined critical thinking as enhancing students' questioning and information-seeking skills, essential for cognitive engagement in learning through higher-level processing. In the same way, Ennis (2018) characterized critical thinking as disciplined reasoning aimed at determining beliefs or actions, involving conceptualizing, applying, analyzing, synthesizing, and evaluating information from various sources. In the same token, Wechsler *et al.* (2018) described critical thinking as a complex process requiring high-order reasoning to achieve intended outcomes. It encompasses evaluating knowledge sources, verifying information validity, and creating explanations for tasks or situations.

Teaching strategies in fostering problem-solving and critical thinking skills in EFL high school students

Horntvedt *et al.* (2018) asserted that effective teaching strategies include clear, concise learning materials and ongoing evaluations. These strategies should be systematic to enhance student interest in learning through engagement. In the same way, Olatunde (2020) emphasized that effective teaching strategies must be adapted based on topic, student age, resources, and classroom environment to positively influence learning outcomes and cultivate problem-solving and critical thinking skills. While Abdulrahman (2018) contended that teaching strategies comprise deliberate goals and teacher behaviors structured as "cognitive action sequences" to foster problem-solving and critical thinking in EFL contexts. Similarly, Cook (2018) stressed the necessity for students to develop critical thinking abilities to analyze, synthesize, and reflect on their learning processes.

Assessment methods to promote problem-solving and critical thinking skills

According to Kumar *et al.* (2023), self-assessment and peer assessment are popular methods for engaging learners in measuring their progress towards learning objectives. Asri (2019) proposed assessments should evaluate candidates' abilities to apply knowledge to real-world problems, focusing on cognitive competencies like critical thinking. In the same token, León (2021) emphasized formative assessments' role in fostering student growth through ongoing feedback, helping identify strengths and weaknesses that are crucial for developing critical thinking skills. Rahman (2019) argued that educators cultivate critical thinking and problem-solving through structured

cognitive challenges. Assessments mirroring authentic contexts—facilitated via technology, peer collaboration, and reflection—help EFL learners advance from replicating language to applying it strategically for creative solutions. Teacher support, metacognitive components, and iterative redesign are critical to this shift.

Context description

This research aims to identify the existing levels of problem-solving and critical thinking skills in writing and reading skills and to assess the effectiveness of instructional strategies and interventions for enhancing them in writing and reading skills. Forty high school (ninth grade) students from Zamora City, Ecuador whose age ranged from 13-14 years were divided into two groups: a control group of 20 students without any reading and writing strategy intervention and an experimental group of 20 students that received such intervention. Both groups had an A1 level of English proficiency. The research began with a literature review through scientific articles, journals, and online books to establish theoretical foundations related to reading and writing strategies, focusing on critical thinking, logical reasoning, and problem-solving.

Cluster analysis

This section comprehends the data gathered and interpreted from the control and experimental group regarding the students' pre-test and post-test. Especially to measure the knowledge that the experimental group gained after having participated in the instruction with reading and writing strategies for fostering problem-solving and critical thinking. How effective are strategies for developing problem-solving and critical thinking skills in reading and writing skills?

Table 1. Pre and post-test

Control group		Experimental group	
Pre-Test	Post-Test	Pre-test	Post-test
5,34	5,39	5,29	8,75
20 students		20 students	

Note. EFL high school students scores of the control and the experimental group

Table 1 presents the results for the control and experimental groups in both the pre-test and post-test. The control group had a pre-test average of 5.34 out of 10 points, which slightly increased to 5.39 in the post-test. This analysis highlights the impact of not using strategies to enhance problem-solving and critical thinking in reading and writing skills, revealing that students struggle to progress beyond basic comprehension without these skills. Consequently, students lacking these abilities may face challenges in higher education and

professional environments, as they are essential for academic success.

In contrast, the experimental group achieved a pre-test average of 5.29 out of 10 points, which rose significantly to 8.75 in the post-test after implementing problem-solving and critical thinking strategies. This increase of 3.46 points demonstrates that consistent application of these techniques prepares students for academic and career challenges. The strategies encourage critical thinking and exploration of diverse perspectives, fostering creativity and innovation for real-world problem-solving.

These findings align with Alberida *et al*. (2022), who noted that employing problem-solving and critical thinking strategies tailored to students' varying academic abilities can address the challenges of 21st-century learning. Their research indicates that students with strong critical thinking and problem-solving skills are better equipped to navigate diverse challenges, evaluate information effectively, and succeed in today's globalized world.

Table 2. Pre and post-tests results obtained by the experimental group

Types of strategies	Experimental group	
	Pre-Test	Post-Test
Strategies for Problem-Solving and Critical Thinking in Reading Skills	5,62	8,63
Strategies for Problem-Solving and Critical Thinking in Writing skills	4,96	8,87
Total average	5,29	8,75
N*	20	

Note. Scores obtained with different types of strategies applied for fostering problem solving and critical thinking in reading and writing skills.

Table 2 presents the outcomes of applying targeted strategies to improve reading and writing skills, with a focus on enhancing problem-solving and critical thinking in the classroom. In reading, the experimental group's average score rose from 5.62 to 8.63 out of 10, marking a 3.01-point gain. This progress highlights the strategies' effectiveness in promoting deeper engagement with texts, fostering curiosity, and encouraging collaborative learning. Students asked more questions, shared ideas, and gained broader perspectives, improving their comprehension and teamwork. These findings are supported by Horntvedt *et al.* (2018), who noted that well-structured teaching strategies stimulate interest and facilitate effective learning.

For writing skills, the experimental group showed an even greater improvement, increasing from 4.96 to 8.87, a 3.9-point gain. The strategies helped students better understand writing tasks, explore ideas more freely, and organize their

thoughts with greater confidence. Writing became less intimidating and more creative, as peer feedback and collaboration helped students recognize their strengths and areas for growth. This aligns with Lestiyanawati (2020), who emphasized the importance of student-centered methods and peer collaboration in enhancing classroom engagement.

Overall, the average score for the experimental group improved from 5.29 to 8.85, representing a 3.56-point increase across reading and writing skills. The six-week intervention clearly contributed to students' ability to comprehend, analyze, and communicate more effectively. The strategies not only strengthened academic performance but also helped students manage complex information and express their ideas clearly in different contexts.

Table 3. Strategies for problem-solving and critical thinking in reading and writing skills

Strategies for Problem-Solving and Critical Thinking in reading and writing Skills	Teaching Strategies	Week	Average	Total
In Reading Skills	Open-ended discussions	1	8.25	9,02
	Ask questions and find answers	2	9.38	
	Peer collaboration and discussions	3	9.45	
In Writing Skills	Brainstorming and exploration of ideas	4	8.15	8,56
	Peer collaboration	5	8,62	
	Constructive feedback	6	8,92	

Note. Students' scores obtained during the application of strategies for Problem-Solving and Critical Thinking in reading and writing skills.

Tables 3 and 4 summarize the results of the intervention in terms of strategy effectiveness and student perceptions. Table 3 outlines the types of strategies applied to foster problem-solving and critical thinking in both reading and writing, along with weekly average scores. Table 4 presents the results of a perception survey that gathered students' opinions on each strategy used.

Table 4. Students' perception survey

Strategies for Problem-Solving and Critical Thinking in Reading Skills	Strongly agree	Agree	Disagree	Strongly disagree	Total
Open-ended discussions					
1. Did the open-ended discussions applied improve my approach to	30%	70%	0%	0%	100%

reading and reflecting on and interpreting texts?					
2. Did open discussions help me better understand a passage and get through reading activities?	30%	50%	15%	5%	100%
Ask questions and find answers					
3. Am I now better prepared to answer questions, express ideas and opinions in a coherent way?	30%	60%	10%	0%	100%
4. Did my ability to adequately comprehend reading activities evolve when asked a question according to the text?	25%	65%	10%	0%	100%
Peer collaboration and discussions					
5. Did working collaboratively with peers' influence decision-making to understand and seek solutions in reading activities?	40%	60%	0%	0%	100%
6. Did sharing ideas and discussing with peers improve my ability to generate and evaluate solutions?	35%	60%	5%	0%	100%
Strategies for Problem-Solving and Critical Thinking in Writing Skills	Strongly agree	Agree	Disagree	Strongly disagree	Total
Brainstorming and exploration of ideas					
7. Did brainstorming help articulate thoughts coherently to solve problems?	25%	60%	15%	0%	100%
8. Are you now able to communicate ideas, opinions, and persuade others?	35%	60%	5%	0%	100%
Peer collaboration					
9. Have your problem-solving skills improved because of peer-to-peer collaboration?	40%	60%	0%	0%	100%
10.Did peer-to-peer collaboration influence your ability to come up with practical solutions?	25%	55%	20%	0%	100%
Constructive feedback					
11. Did the teacher's corrections and help in the writing activities motivate you to find the solution that best solves the problem?	50%	50%	0%	0%	100%
12. Are you now able to recognize your weaknesses to grow in your role and	45%	55%	0%	0%	100%

improve your performance by overcoming obstacles?	

Note. Students' perception survey based on critical thinking and problem-solving reading and writing strategies.

One of the reading strategies implemented was open-ended discussions, which led to an average score of 8.25 out of 10—rated as good. Survey results showed that 70% of students agreed and 30% strongly agreed that this strategy helped them improve how they read, reflected on, and interpreted texts. Classroom observations supported this, revealing that open discussions encouraged students to share their ideas more freely, listen to different perspectives, and better understand the readings by exploring multiple interpretations. These findings align with Martin and Bolliger (2018), who highlighted the value of open-ended discussions in promoting reflection and participation. Additional student feedback on this strategy showed that 50% agreed, 30% strongly agreed, 15% disagreed, and 5% strongly disagreed about its benefits for comprehension. Observations further confirmed that students engaged more, asked clarifying questions, and showed greater confidence in discussing complex ideas.

The second reading strategy—asking questions and finding answers—was even more effective, with an average score of 9.38 out of 10, rated as excellent. According to the survey, 60% of students agreed and 30% strongly agreed that the strategy helped them answer questions more coherently, while 10% disagreed. This approach improved their ability to evaluate the relevance of texts, explore different meanings, and stay focused. It also helped them retain more information. These outcomes are consistent with Callohuanca (2021), who emphasized the link between questioning and reflective reading. When asked specifically about reading comprehension improvement through this method, 65% agreed, 25% strongly agreed, and 10% disagreed. In the classroom, students demonstrated a better understanding when questions were closely connected to the texts, which helped them focus and grasp key ideas—an observation supported by Elleman and Oslund (2019), who pointed to the importance of context in reading comprehension.

Peer collaboration was the third reading strategy used, resulting in an average score of 9.45 out of 10, also rated as excellent. When asked if collaboration influenced their decision-making in reading activities, 60% agreed and 40% strongly agreed. Working with peers helped students summarize texts, give feedback, and exchange ideas, exposing them to different points of view and building a sense of teamwork. These findings support Lestiyanawati (2020), who noted that collaboration boosts engagement among high school learners. In terms of whether idea-sharing led to better solutions, 60% agreed, 35% strongly agreed, and 5% disagreed. Students reported feeling more confident and

motivated during group work, which echoes Kumar *et al.* (2023), who found that collaboration enhances teamwork and student interaction. Altogether, the reading strategies—open-ended discussions, questioning, and collaboration—promoted deep engagement with texts through inquiry and shared learning. The overall average score for the reading strategies was 9.02 out of 10.

In writing, the study applied three strategies: brainstorming and idea exploration, peer collaboration, and constructive feedback. Brainstorming scored an average of 8.15 out of 10 (good). According to the survey, 60% of students agreed and 35% strongly agreed that this approach helped them express their thoughts more clearly, while only 5% disagreed. It created a space where they could explore ideas freely, organize their thinking, and communicate more effectively as confirmed in the findings of Widiastuti *et al*. (2022), who emphasized the empowering nature of brainstorming in the classroom.

Peer collaboration in writing earned an average of 8.62 out of 10, also rated as good. Survey responses showed that 60% agreed and 40% strongly agreed that this strategy helped them improve their problem-solving abilities, while 55% agreed, 25% strongly agreed, and 20% disagreed that it helped them find practical solutions. Through collaborative tasks, students learned to exchange and refine ideas, improving their communication and teamwork skills.

Finally, constructive feedback received the highest average among the writing strategies—8.92 out of 10 (good). Students responded positively to teacher feedback, with 50% agreeing and 50% strongly agreeing that it motivated them to improve. Regular feedback helped them identify errors and encouraged them to keep progressing, creating a cycle of improvement.

Overall, the writing strategies provided meaningful opportunities for students to strengthen both their critical thinking and problem-solving skills while also fostering creativity and collaboration. The combined average score for writing strategies was 8.56 out of 10.

Conclusions

This article highlights how combining specific reading and writing strategies can significantly enhance high school students' problem-solving and critical thinking skills. Reading approaches like questioning and searching for answers promote active engagement, collaborative learning, and diverse perspectives, which help students analyze and interpret texts more effectively. Writing strategies such as peer review and constructive feedback encourage creativity, reflection, and continuous improvement, leading to better-quality writing. Among all the strategies, peer collaboration was the most impactful in both reading and

writing, strengthening students' communication, teamwork, and shared problem-solving abilities. The "ask questions and find answers" strategy stood out in reading for improving focus and comprehension, while constructive feedback proved especially effective in writing by helping students identify strengths and areas for growth. Overall, the use of these interconnected methods fosters active participation, deepens understanding, and boosts academic performance, ultimately equipping students with essential skills to face academic demands and real-world challenges with greater confidence.

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Teaching contexts in Colombia: Interactions and knowledge

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Introduction

Contemporary education is being redefined by new patterns of knowledge circulation characteristic of the knowledge society, where each territory generates technical and technological devices mediated by cultural dialogue, dialectical or dialogical (Panikkar, 2007), and by diverse pedagogical approaches. From Quintanilla's perspective (2016), technology is neither neutral nor autonomous, but rather a cultural construct laden with human values. This perspective allows us to understand teaching as situated knowledge, sensitive to local conditions of educability. Technique and technology are understood as forms of know-how, expressed in pedagogical practices that value diversity and promote dialogue, differentiating between artisanal (non-systematised) and industrial (systematised) knowledge. Techniques emerge from community experience and are transmitted through cultural practices, while industrial technologies, born of the Industrial Revolution, are derived from scientific knowledge and incorporated into education through analogue and digital tools. This study proposes three areas for analysing their use: techniques or technologies for information and communication (TTIC), for learning and knowledge (TTAC) and for empowerment and participation (TTEP). It also recognises different scales of knowledge circulation: in the Global–Local relationship, knowledge from the geopolitical north is appropriated and adapted locally; in the global-global relationship, knowledge circulates without territorial anchoring (Sarsanedas, 2015); in the local-local relationship, knowledge responds to specific cultural contexts; and in the local-global relationship, the local is projected globally through processes such as systematisation or participatory action research (Mejía, 2015).

Fieldwork and data analysis

The fieldwork was carried out by students from the Master's Degree in Inclusive and Intercultural Education at UNIMINUTO, as part of the Latin American Node project: Knowledge in terms of technique and technology, under the direction of the lead teacher, author of this chapter. The collection of information was based on inclusion and exclusion criteria to document teaching practices related to the subject of study, including twelve experiences in Colombian municipalities that are diverse in geographical, cultural and social terms. These were

distributed across formal, non-formal and informal educational settings, covering ancestral, empirical and academic knowledge. In informal contexts, practices such as pottery (Pitalito), zoomorphic masks (Galapa), healing the evil eye (Condoto), tobacco cultivation (Los Santos) and potato cultivation (Pupiales) were recorded; in non-formal spaces, experiences such as dance (Sabaneta) and strawberry cultivation led by women (Yarumal); and in formal settings, educational radio initiatives (Medellín, San José del Guaviare and Inzá), a flexible model of adult education (Bogotá) and the use of the Silva Digester Paca (Duitama). The analysis was based on observation diaries and photographic records, systematised according to the objectives of the study.

This chapter is structured around two main categories, life technic and industrial technologies, which serve as interpretative frameworks for understanding how teaching processes are conceptualized in the Colombian context. These processes are based on situated experiences that vindicate local knowledge and educational practices beyond the formal sphere. In this approach, education incorporates cultural devices, both conceptual and material, that diversify and broaden the educational horizon. The role of the teacher transcends institutional professionalisation: they are the ones who socialise knowledge from and for the community.

Techniques for life

This category brings together ancestral, empirical, and traditional knowledge that is transmitted through relationships, outside of the school curriculum. This knowledge is rooted in the territory, built up in everyday life and validated by the community. It represents forms of cultural resistance that challenge the instrumental rationality of the system (Dussel, 1994; Mignolo, 2003; Quijano, 2000), and its pedagogical significance lies in preserving one's own identity in the face of hegemonic models.

Potter's Hands Workshop (Pitalito, Huila)

Located in the Solarte neighbourhood, this workshop is a space for preserving and sharing pottery knowledge, rooted in oral tradition and everyday practice. The learning process begins with an understanding of the properties of clay from the Laboyos Valley, its texture, colour and elasticity, and continues with specific techniques such as centring, modelling with the fingertips, and the use of different pressing techniques (bow tie, buried and cut) (Observation diary, Chapuesgal-Chacua, 2023).

Figure 1. Technique for making pottery pieces.



The process is collective: each member of the family or community plays a role, from gathering the material to marketing the pieces. The master craftsman or craftswoman, a figure of experience and respect, transmits knowledge through oral storytelling filled with anecdotes and rigorous practice that transforms the material into a cultural object. The technique is both an expression of identity and a form of cultural resistance that links the past and the present.

Zoomorphic Masks (Galapa, Atlántico)

Galapa is renowned for its syncretic festivities, the result of the fusion between indigenous, Afro-descendant, and settler communities. These celebrations express myths, connections with nature, and forms of coexistence based on cultural dialogue. A central symbol is the zoomorphic masks, whose origin is linked to African heritage and whose production, according to Almario-Blanco (2023), follows traditional techniques transmitted orally. These masks embody a spiritual and symbolic legacy that is also manifested in events such as the Barranquilla Carnival.

Figure 2. Making zoomorphic masks.



Healing of the Evil Eye (Condoto, Chocó)

In areas where access to healthcare is limited, ancestral knowledge sustains life and well-being. Healers, through spiritual and botanical knowledge, practise techniques learned through oral tradition, linked to the environment and deities. These techniques, far removed from the biomedical model, face risks from mining and the use of chemicals: 'The herbs that are remedies are dying... if they survive, they are contaminated' (Murillo-Castro, 2023). Each healer has a

particular emphasis, and their treatments combine plants, prayers, and physical observation. 'If you find one finger longer than the other... the child is bewitched' (Murillo-Castro, 2023). Despite technological advances, this knowledge persists as living practices of healing and resistance. 'Here we are willing to continue working for the health of the people of Condoto' (Murillo-Castro, 2023).

Figure 3. Healing process for the evil eye.



Anaconas Dance Group (Sabaneta, Antioquia)

Dance is part of the daily life and rituals of communities, serving as an intergenerational bridge that reflects cultural diversity. In Sabaneta (Antioquia), teachers from formal educational institutions have found in dance a pedagogical space to strengthen bonds, promote collaboration, and revive traditional expressions such as bambuco, pasillo, cumbia, and carranga.

Figure 4. Anaconas Dance Group Meeting.



The Anaconas group teaches dance from a cultural perspective, using physical routines that combine stage memory, corrected execution, and energetic expression. This practice integrates body, rhythm, and cultural knowledge in harmony with local worldviews. 'The body integrates with the music, creating a complementary rhythm that harmonises with the beat of the piece' (Greco-Donado, 2023).

Tobacco cultivation (Los Santos, Santander)

In Santander, tobacco cultivation is an ancestral practice that has been preserved through oral tradition and family experience, especially among rural and ethnic communities (Tapia, 2019). This activity, deeply rooted in culture, is passed down from generation to generation, with elders—heads of households—acting as teachers who guide each stage of the process. The knowledge taught ranges from the sensory selection of seeds (by touch, smell and colour), the preparation of the soil with organic fertilisers such as cow and camuro excrement, to rituals of gratitude to Mother Earth. During planting, the seeds are covered with straw to protect their development (Field diary, Almeida-Almeida, July 2023). The work is distributed according to the abilities of each family member and, in some cases, according to gender: 'The opening or smoothing of tobacco is mainly done by women, without ignoring the role played by men...' (Almeida-Almeida, 2023, p.1).

Figure 5. Teaching tobacco planting.



Harvesting takes place approximately two months later, during which time traditional techniques are used to protect the crop from pests. At this stage, young people are taught the technique of desbarejado — removing the leaf with the thumb and picking it up with the rest of the hand — a skill that requires precision and practice. The success of this work guarantees quality leaves for their 'encarrado,' that is, their grouping into bundles ready for sale (Field diary, Almeida-Almeida, July 2023).

Potato cultivation (Pupiales, Nariño)

Indigenous communities preserve ancestral knowledge about potato cultivation, transmitted orally and through practice, along with rituals that reaffirm their spiritual connection to the land. The process begins with the careful selection of seeds—based on their size and healthy appearance—and with teaching about crop rotation, a fundamental practice for maintaining productivity and preventing disease (Field diary, Arciniegas-Chamorro, June 2023). The preparation of the land combines agricultural techniques with symbolic gestures:

the soil is touched and felt, gratitude is expressed, and a spiritual connection is established. Homemade fertiliser made from pig, guinea pig and rabbit manure is applied, carefully distributed so as not to affect the seeds. At the end of the harvest, the community performs a ritual of thanksgiving that brings together syncretic elements expressing the cultural richness and diversity of the people.

Figure 6. Teaching potato planting.



'I have come to greet Mother Potato, I have come to greet the new potato... You will encounter hailstorms and snowfall' (Arciniegas-Chamorro, August 2023), sang the wise Álvaro Chicunque during the ritual, as he danced with precision around sacred objects in honour of Pacha Mama. Every gesture and song conveys generational knowledge, materialised through bodily expression and spoken word.

Industrial techniques

Industrial technologies are characterised by being systematised devices that offer conceptual and practical tools, learned through routines that articulate means and ends. These technologies facilitate integration into the modern world, either through physical devices—such as computers, smartphones, or the internet—that enable the circulation of knowledge, or through conceptual, political, aesthetic, and ethical technologies that shape social and community life, promoting discourses on gender, migration, and social inclusion within contemporary institutional and cultural frameworks.

Strawberry cultivation (Yarumal, Antioquia)

This experience seeks to redefine the role of rural women through collective strawberry cultivation, challenging the traditional patriarchal division of agricultural labour, where planting has historically been assigned to men. Through the exchange of knowledge, women organise themselves into a collective that promotes their empowerment and economic autonomy, giving

visibility to voices that were previously relegated to the sphere of care (Field diary, Arango-Cifuentes, July 2023).

Figure 7. Strawberry cultivation.



The process begins with preparing the soil, sowing, tending and harvesting, stages in which each woman brings her unique knowledge. This collective work not only transforms agricultural practices, but also constitutes an emancipatory exercise that reclaims and redifines women's place in the territory.

Paca Silva digester (Duitama, Boyacá)

The Silva Digester Paca is a social technology that emerged from a research process that systematised knowledge and designed a replicable methodology using educational materials. Its implementation has given rise to the 'paqueros' collective, who promote this technique in dialogue between rural and urban areas, mainly in urban contexts (Ossa-Carrasquilla et al., 2021). The technique is taught in practice, through discussion groups, field trips and community actions in public spaces. 'In the trainer training programme, the history of the technique is shared, highlighting that it arises from the natural process of the forest' (Field diary, Moncada-Martínez, June 2023).

Figure 8. Silva Digester Bale.



The process begins with the installation of a wooden mould on the ground to allow drainage. A base is created with dry plant material, and then layers of

chopped waste and vegetation are interspersed until the mould is filled. The installation is accompanied by environmental awareness spaces on waste management and collective land construction.

School radio (Medellín, Antioquia, San José del Guaviare, Guaviare, and Inza, Cauca)

School radio is set up as an educational tool that brings together knowledge from three educational institutions—rural and urban—integrating communication and education as complementary academic fields. The techniques and technologies used, both analogue and digital, strengthen student and community participation, while promoting contextualised training processes. These experiences share a common fabric based on the tradition of Radio Sutatenza (1947), revitalised today through the Ondas programme, and are developed in dialogue with the school curriculum. At the Santander Educational Institution in San José del Guaviare, the use of community radio stations such as Juventud Stereo 104.7 FM allows content to be broadcast in analogue spaces, while at the Enrique Olaya Herrera Institution in Medellín, the Zeno FM digital platform and editing software enhance the global circulation of content.

The Luis Nelson Cuellar Agricultural Institution in Inzá (Cauca) is developing its school radio project in a context marked by technological gaps that limit its dissemination beyond the educational environment, especially on AM/FM media, while also facing cultural tensions related to family restrictions and religious beliefs: "The student (...) responds that he does not have an account because his parents do not yet allow him to use social media. Another student (...) also states that his parents are very restrictive, especially because of their religious beliefs..." (Observation diary, J. Torres-Camacho, July 2023). The training of school radio broadcasters, which is largely non-curricular, is woven from experience through horizontal pedagogical relationships between teachers and students. In Medellín, emphasis is placed on vocalisation, breathing and script construction (Valencia-Henao, 2023); in San José del Guaviare, voice management, templates and dialogue strategies (Bejarano Rentería, 2023); and in Inzá-Cauca, fluid conversation and role organisation (Torres-Camacho, 2023). In these different contexts, school radio redefines the use of technology as a means of socialising knowledge, revitalising educational processes and strengthening the local educational fabric.

Flexible education Mochuelo (Bogotá, Cundinamarca)

This experience takes place in a formal education setting for adults seeking to complete their basic and secondary education, through a contextualised education programme that combines communication, logical-mathematical,

scientific, social and environmental skills. The classroom expands into the community through community strategies such as the collective pot, promoted in meeting places such as religious festivals, where traditions and cultural ties are reflected upon. In the Mochuelo neighbourhood, located on the border between urban and rural areas, traditional practices are preserved in dialogue with the demands of modern institutions. There, learning is based on projects, cooperation, experience and self-training, integrating conceptual industrial technologies aimed at empowerment, participation and inclusion in the organisational frameworks of the state. Although knowledge comes from community practices, its systematisation allows formal educational goals to be achieved and the social fabric to be strengthened from an intercultural perspective (Field diary, Gómez-Ardila, Corredor-Gómez and Alejo-Durán, August 2023).

Figure 9. Mochuelo encounter scenario.



Conclusions

Discourses on technique and technology have been marked by the hegemony of Western thought, which seeks to universalise its postulates and present itself as the pinnacle of civilisation (Kuper, 2008; Panikkar, 2007); however, human and territorial diversity offers other forms of knowledge that engage in dialogue, resist and reconfigure this model. The pedagogical experiences analysed reveal knowledge that emerges from local routines, from rural and urban areas, in liminal zones where the ancestral, the empirical and the academic intersect. In Colombia, education transcends formal schooling and incorporates cultural practices that resist homogenisation, articulating the local with ethical, political and aesthetic elements of the Western world. Thus, it redefines the technical and technological from its territories to preserve, transform and project life, giving rise to situated pedagogical itineraries that deserve to be recognised in global educational debates.

The experiences documented across diverse Colombian territories, ranging from pottery and mask-making to community radio and organic cultivation, demonstrate that technical and technological knowledge is not only transmitted but transformed through culturally embedded pedagogical practices. These processes emerge in intergenerational contexts where learning is oral and symbolic, often led by elders, artisans, or local educators who embody communal authority. Whether in the healing rituals of Condoto, the rhythmic choreography of Sabaneta, or the agroecological cycles of Pupiales and Los Santos, technique is not isolated from culture but intricately interwoven with spirituality, aesthetics, and social bonds. Even in industrial or systematised spaces, such as the Paca Silva digester or school radio stations, the appropriation of technology is shaped by local logics of cooperation, resistance, and adaptation. Thus, these situated pedagogies challenge the universality of hegemonic technological paradigms by generating hybrid models that link ancestral knowledge with contemporary tools, asserting epistemic autonomy and forging alternative educational horizons.

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Heritage education in neighborhood associations in Sullana, Peru

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Introduction

Heritage education is presented as an alternative to the scarcity of initiatives aimed at defending and conserving world heritage. The appreciation of cultural heritage in different territories promotes cultural identity and helps inhabitants take ownership of their legacy. In 1931, with the Athens Charter, the first steps were taken towards the development of heritage education, focused on the conservation of artistic and historical monuments. Later, in 1970, UNESCO in Paris promoted programs to encourage heritage education, aimed at raising awareness in society about its care, as well as proposing measures to prevent the illegal import, export, and transfer of cultural property (Sanz, 2020).

Several recent studies indicate that heritage education contributes significantly to the construction of local and community identity. Through educational experiences (itineraries, on-site activities, school projects), people internalize the history and meanings of their environment, which translates into greater commitment to conservation and the ability to articulate heritage with local development initiatives. This reinforces the idea that heritage education should begin in childhood, but it should also be linked to ongoing community processes to consolidate the social appropriation of heritage (Dordio et al., 2024).

In the Peruvian context, the General Heritage Law, Law No. 28296, enacted in 2004, promotes the appreciation and conservation of historical and traditional resources through education. This regulation coordinates actions between national, regional, and local agencies, strengthening mechanisms for the protection and management of elements that make up community identity. Since 2006, awareness campaigns have been developed with the participation of volunteers in defense of heritage, through visits, inspections, clean-up days, and talks in representative spaces. In 2013, the "Caminantes del Qhapaq Ñan" program consolidated the link between the population and historical elements,

with a special focus on children and young people, seeking to strengthen cultural identity and a sense of belonging (Ventura and Contreras, 2017).

In Sullana, according to the Concerted Municipal Development Plan, although the tourist and archaeological potential is recognized, problems such as the lack of tourist infrastructure, citizen insecurity, and weak promotion of cultural attractions persist. Given this situation, heritage education is proposed as a key strategy for conservation, as valuing heritage strengthens cultural identity and citizens' ownership of their legacy (Municipalidad Provincial de Sullana, 2021).

Local governments, provincial and district municipalities, and population centers have a responsibility to implement coordinated actions that reflect an ethical and sustainable commitment to cultural preservation. In this context, the departments and sub-departments of Culture and Tourism play a fundamental role in linking heritage with community identity, job creation, and local development. This requires a regulatory framework that supports the enhancement of heritage through municipal ordinances and the promotion of public investment, protected by the Organic Law of Municipalities (González, 2023).

However, cultural management in local governments remains limited, particularly in the implementation of educational programs. Despite the powers granted by the Organic Law on Municipalities, in practice there are few training and awareness-raising strategies, especially in neighborhood councils, where ignorance of the value of cultural resources restricts citizen participation in conservation and dissemination (González and Rúa, 2022).

Heritage education in neighborhood councils is essential to strengthen identity and belonging, but the absence of training programs has led leaders and members to be unaware of the cultural value of their environment and the actions needed for its preservation. This weakness limits community participation in conservation projects.

Today, digital tools offer innovative alternatives. One example is the study: Innovation: QR Code in Heritage Education for Tourism in Sullana, which developed a web repository, generated QR codes, and surveyed 65 participants. The results showed 46.15% acceptance of this tool, highlighting the importance of accessible formats that integrate images, text, and video to improve heritage education and the tourist experience.

Heritage assets must become catalysts for synergies between authorities and civil society to strengthen collective identity and well-being. Although there are intentions to preserve, these often do not translate into concrete actions. Heritage education contributes not only to the transmission of knowledge but

also to the generation of citizen engagement. This is demonstrated by the study "Perception of the significance of heritage assets in the community" conducted in Quiruvilca (2021), where 95% of participants expressed a strong sense of belonging to the local heritage (González, 2022).

Several studies point to the lack of heritage education as one of the main causes of weak cultural identity in Sullana. Strengthening culture involves gradual and coordinated work with the 84 existing neighborhood associations, integrating them into a common effort to preserve the region's archaeological heritage.

From a theoretical perspective, heritage education is conceived as the link between cultural heritage and personal development, a process that begins in the family and continues in school (García, 2021). Teaching in childhood is crucial for generating local identity and promoting conservation (Peinado, 2020). During the 21st century, heritage education has become established as an interdisciplinary pedagogical strategy that connects students with their cultural environment (Quijano, 2020). In addition to cultivating identity, this teaching should promote inclusive and sustainable learning (Pinto, 2021; Venturo et al., 2024). In this sense, its objective is to raise awareness among the population and generate a willingness toward conservation and more sustainable tourism practices (Fontal, 2016; Venturo, 2021; Romera et al., 2024).

Regarding the dimensions of research, Vizcaíno et al. (2023) define it as the process of collecting, analyzing, and interpreting information, while Costa (2024) relates it to the constant acquisition of knowledge. Perception, according to Alonso (2021), combines stimuli, prior knowledge, and emotions to generate individual interpretations. Likewise, the enhancement of heritage seeks to highlight its attributes and benefits (Mollenhauer et al., 2020), with a legal background that understands it as a set of assets and traditions that make up the identity of a territory (Sardiñas et al., 2024). Cepeda (2018) adds that teaching heritage allows us to understand its origins and to understand archaeological remains as living witnesses to history.

Communication is understood as the exchange of information through different media (Vaca, 2024), where content is transmitted through images, texts, or videos (Zambrano et al., 2024), and its dissemination is carried out through various channels such as social networks, radio, or television.

At the international level, studies have been conducted linking heritage education and sustainable tourism. Song et al. (2024) analyzed tourist demand for cultural heritage, highlighting attributes of authenticity and sociodemographic characteristics as determinants of visits. McKenna and Hanrahan (2024) explored sustainability indicators in Ireland, highlighting the

importance of community participation in tourism planning. Jiménez (2023) emphasized the role of science and technology in cultural management, while Trabajo and Cuenca (2022) demonstrated how heritage education fosters critical awareness and sustainability in students. Guillén et al. (2022) evaluated the dissemination of heritage education in tourist areas in Spain, highlighting the importance of integrating pedagogical components.

At the national level, Frech (2023) highlighted knowledge management as key to tourism resilience in Oxapampa. Quijano and Jiménez (2020) showed how archaeological itineraries strengthen learning in tourism students, and Quijano (2019) demonstrated the impact of heritage education on the development of investigative pedagogical skills.

In Sullana, local research such as that of Piñarreta et al. (2023) confirms the acceptance of heritage education among university students, identifying correlations between culture, economic investment, and tourist information. Luján et al. (2023) analyzed the province's tourism potential, although they noted the lack of adequate infrastructure. Arrizabalaga (2022), for his part, studied the theatrical representation of Tallán identity, highlighting its role in building local pride.

Thus, the research poses the following general question: What is the level of knowledge of the neighborhood councils of Sullana about heritage education? The objective is to describe the level of knowledge about heritage education in the neighborhood councils of Sullana, describe the perception of the neighborhood councils regarding research on heritage education, analyze the perception of the enhancement of local cultural heritage, and evaluate the communication strategies used for its dissemination.

Neighborhood councils of Sullana - Peru

A total of six neighborhood councils were involved: Zapata Silva Human Settlement, 09 de Octubre Human Settlement, Villa María Town Center, Santa Rosa Urbanization, Buenos Aires Neighborhood, and Barrio Sur Neighborhood. In this regard, the sample size totals 50 members of these neighborhood councils, who are actively involved in the organization.

Perception of neighborhood associations in Sullana regarding research related to heritage education

To describe the perception of neighborhood associations in Sullana regarding research related to heritage education, two main indicators were considered: knowledge and perception of heritage education. The results of the questionnaire administered before the talk (pretest) show that 84% of

neighborhood council representatives strongly disagreed with the statement about the contribution of heritage education to community, 14% disagreed, and only 2% were undecided, reflecting a very low perception of the relevance of heritage education. However, after the talk, the results of the post-test questionnaire showed a significant change, with 86% of representatives expressing strong agreement with the statement, while 14% agreed, demonstrating a considerable increase in knowledge and perception of heritage education.

Information on the benefits of heritage education provided by the Ministry of Culture

A substantial change in the willingness to receive information on the benefits of heritage education from the Ministry of Culture, as before the talk the representatives were reluctant to do so, with 54% indicating that they totally disagreed, 44% disagreed, and 2% were undecided. However, after the talk, 70% said they strongly agreed with this question and 30% agreed, highlighting the importance of raising awareness of the benefits of tourism and heritage care and preservation, as this can generate opportunities for local development.

Dissemination of research on heritage education

The communication strategies used to disseminate heritage education in the neighborhood councils of Sullana focused on two indicators: content and dissemination. Regarding content, the majority of representatives disagreed with the dissemination of research on heritage education, with 50% strongly disagreeing and 46% disagreeing, indicating indifference towards the importance of disseminating this research.

However, after the talk, a significant change was observed, with 52% agreeing and 48% strongly agreeing, reflecting a significant improvement in the representatives' perception of the need to disseminate research on heritage education, resulting in increased awareness and commitment to this issue.

Dissemination of research on heritage education in the media

Regarding the dissemination of research on heritage education, there is a lack of interest in the media playing an active role in disseminating this type of research. However, after the talk, 72% strongly agreed and 28% agreed, indicating a significant change and greater acceptance of the role of the media in disseminating heritage education, assigning a more dynamic role to the media in cultural valorization.

The level of knowledge about heritage education was initially low, which showed a limited understanding of its relevance both for the conservation of cultural

heritage and for local economic development. However, following the intervention through a specialized talk, there was a significant increase in the level of knowledge among neighborhood councils, who recognized its potential to contribute to tourism development and community income generation. This change was statistically corroborated, showing significant differences between the level of knowledge before and after the intervention.

Similarly, awareness of heritage education research was also low at the outset, particularly with regard to the benefits for the conservation of tourism resources and the creation of new economic opportunities. Subsequently, the talk led to a substantial improvement in this awareness, revaluing research as a strategic tool for tourism and economic development. The results show that the intervention strengthened the neighborhood associations' expectations regarding research in this area, confirming statistically significant differences in their assessments.

At the international level, Jiménez (2023) argues that scientific and technological advances need to be accompanied by social progress, placing heritage education as an essential component in the social appropriation of science. In this process, sociocultural managers and the use of social technologies play a decisive role. This perspective converges with the findings of the present research, since even a brief intervention, such as a talk, improved the neighborhood associations' perception of research in heritage education, associating it with tangible benefits such as resource conservation and economic development. Complementarily, Trabajo and Cuenca (2022) demonstrated that heritage education strengthens identity bonds and fosters critical and committed citizenship, an aspect that is related to the results of this study, which found that this tool generates community understanding and commitment. Likewise, Guillén et al. (2022) emphasize the need to incorporate educational experiences into tourism projects and to disseminate heritage education, a conclusion consistent with the findings of this research, where a simple intervention significantly changed neighborhood associations' perception of the importance of research in this field.

At the national level, Frech (2023) emphasizes knowledge management as a fundamental element in ensuring the resilience and sustainability of tourist destinations, which is related to the results from Sullana, which highlight the urgency of implementing actions aimed at strengthening understanding of heritage value. In turn, Quijano and Jiménez (2020) showed that, although students acquired conceptual knowledge in situ at archaeological sites, their learning was limited to basic levels of understanding. This result contrasts with the findings of the present study, where an informative and structured intervention allowed for higher levels of understanding and expectations related to the impact of heritage research on economic and tourism development.

Similarly, Quijano (2020) demonstrated that the implementation of heritage education improved students' research skills, a finding that is closely related to this research, since, after the talk, the neighborhood associations' perception of the role of heritage research in local development was reinforced.

At the local level, Piñarreta et al. (2023) reported 100% acceptance of heritage education among university students, as well as significant correlations between culture and economic investment (0.726) and between culture and tourist information (0.559). Although the focus of their research differs, their results correspond to those of the present study in highlighting the relevance of heritage education in cultural preservation and in strengthening the sense of belonging.

On the other hand, the neighborhood associations' initial perception of the enhancement of cultural heritage was characterized by attitudes of disagreement regarding conservation, budgetary inclusion, and participation in heritage activities. However, after the intervention, there was a statistically significant improvement in the indicators analyzed, reflecting an increase in community awareness of heritage conservation as a driver of local development.

In the international literature, Song et al. (2024) identified that authenticity attributes and sociodemographic characteristics are determining factors in tourism demand. Although these results focus on the visitors' perspective, they are partially related to this research, as they coincide in the relevance of cultural education programs to strengthen heritage sustainability. Complementarily, McKenna and Hanrahan (2024) highlighted discrepancies between the recognition of tourism benefits (87%) and low satisfaction with community participation in planning (23%). These results are linked to the findings in Sullana, where neighborhood councils initially had low perceptions, but after the intervention showed a positive trend toward the inclusion of heritage in development processes.

Finally, with regard to communication strategies, the initial results reflected a marked disagreement regarding the existence of heritage education programs in museums, digital repositories, and the media, as well as regarding the production of university research related to culture. However, after the talk, a significant change was observed, with increased acceptance of the dissemination and creation of content related to heritage education. This finding represents a step forward in the awareness and commitment of neighborhood associations to cultural communication. It should be noted that no previous studies were identified that directly coincide or differ with this result, making it a novel contribution and opening up a line of future research on the influence of communication strategies on community perception and commitment to

heritage.

Conclusion

The initial knowledge of neighborhood associations in Sullana about heritage education was low; however, after the talk, there was a highly significant increase in levels of understanding, confirming the effectiveness of the intervention in promoting heritage appreciation.

Perceptions of research in heritage education were also limited at the outset, but the educational intervention generated a statistically significant increase, strengthening expectations about its contribution to local tourism and economic development.

In relation to the enhancement of cultural heritage, the results showed a substantial change in the awareness of neighborhood associations, moving from an attitude of disagreement to one of acceptance and commitment to conservation and its link to community progress.

Finally, communication strategies around heritage education were initially little recognized; however, the talk led to a significant improvement in the acceptance of the dissemination and creation of cultural content, demonstrating the potential of educational interventions to strengthen communication and citizen engagement with heritage.

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