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The main objective of the **Latin American Journal of Educational Technology (RELATEC)** is to be a bridge in the Latin American space between experts, specialists and professionals in teaching and research in Educational Technology. It is edited by the University of Extremadura (UEX) and sponsored by the Department of Educational Sciences of the UEX, the University Network of Educational Technology (RUTE) and Nodo Educativo (Research Group).

In **RELATEC** we intend to publish all those scientific contributions related, directly or indirectly, with this wide field of scientific knowledge: research, experiences or theoretical developments, general or focused on specific educational levels. Therefore, university professors, researchers, educational managers, teachers and professors of Early Childhood Education, Primary and Secondary Education, doctoral students, social and political agents related to Education, etc. are invited to collaborate. These are also its main target audience, although its wide dissemination on the Internet means that it is offered to a much more general public, practically the entire international educational community.

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Databases

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EDITORIAL

Twenty-five Years of RELATEC: Scientific Contribution and the Transformation of Educational Technology

Veinticinco años de RELATEC: contribución científica y transformación de la Tecnología Educativa

Jesús Valverde-Berrocoso

Abstract: This article introduces the special section commemorating the 25th anniversary of the Latin American Journal of Educational Technology - RELATEC and reviews its contribution to the consolidation of Educational Technology in the Ibero-American context. First, it presents the journal's editorial and thematic evolution since its foundation, highlighting its shift from early debates on ICT integration, e-learning, virtual platforms and multimedia materials to more complex issues related to digital competence, inclusion, digital citizenship, open science, open education and generative artificial intelligence. Second, it analyses RELATEC's identity as a diamond open access journal, with no fees for authors or readers, and its alignment with the principles of bibliodiversity, transparency, knowledge reuse and public scholarly communication. Third, it examines the journal's consolidation as a quality scientific publication, recognised by the FECYT Seal of Quality and indexed in evaluation and dissemination systems such as ESCI, DOAJ, ERIHPlus, Dialnet, Latindex and Journal Citation Reports. The article also presents the contributions included in the special section, coordinated by Manuel Area-Moreira and Bartolomé Rubia-Avi, and authored by leading scholars in the field of Educational Technology. Overall, the special section offers a critical reading of the current state of the field and outlines RELATEC's main future challenges: internationalisation, open science, sustainability of the diamond model, methodological quality and responsible research assessment.

Keywords: RELATEC, Educational Technology, Open Science, Diamond Open Access, Scientific Journals, Generative Artificial Intelligence, Digital Competence.

Resumen: Este artículo introduce la sección especial conmemorativa del 25 aniversario de la Revista Latinoamericana de Tecnología Educativa - RELATEC y revisa su contribución a la consolidación de la Tecnología Educativa en el ámbito iberoamericano. En primer lugar, se presenta la evolución editorial y temática de la revista desde sus inicios, destacando su tránsito desde los primeros debates sobre incorporación de TIC, e-learning, plataformas virtuales y materiales multimedia hacia problemáticas más complejas vinculadas con competencia digital, inclusión, ciudadanía digital, ciencia abierta, educación abierta e inteligencia artificial generativa. En segundo lugar, se analiza la identidad de RELATEC como revista de acceso abierto diamante, sin costes para autores ni lectores, y su alineación con los principios de bibliodiversidad, transparencia, reutilización del conocimiento y comunicación científica pública. En tercer lugar, se examina su consolidación como revista científica de calidad, reconocida por el Sello FECYT e incluida en sistemas de indización y evaluación como ESCI, DOAJ, ERIHPlus, Dialnet, Latindex y Journal Citation Reports. El texto presenta, además, los artículos que integran la sección especial, coordinada por Manuel Area-Moreira y Bartolomé Rubia-Avi, en la que participan autoras y autores de referencia en Tecnología Educativa. En conjunto, la sección ofrece una lectura crítica del estado actual del campo y proyecta los principales desafíos de RELATEC: internacionalización, ciencia abierta, sostenibilidad del modelo diamante, calidad metodológica y evaluación responsable.

Palabras-clave: RELATEC, Tecnología Educativa, Ciencia Abierta, Acceso Abierto Diamante, Revistas Científicas, Inteligencia Artificial Generativa, Competencia Digital.

1. Introduction

The commemoration of the 25th anniversary of the Revista Latinoamericana de Tecnología Educativa – RELATEC constitutes a particularly significant occasion to review the trajectory of a publication that has contributed to the construction of the field of Educational Technology in the Ibero-American context. Since its inception, RELATEC has defined itself as a biannual scientific journal, peer reviewed through a double-blind system, edited by the University of Extremadura, and devoted to the dissemination of research on Educational Technology, with a clear Latin American, multilingual, and international vocation.

The history of RELATEC can be read as a history running parallel to the evolution of Educational Technology itself. In its early years, the journal addressed debates related to the incorporation of ICT into educational systems, online learning, e-learning platforms, multimedia materials, and the first experiences of technology-mediated innovation. Over time, its scope expanded towards issues of greater pedagogical, institutional, and sociocultural complexity: technology integration policies, teachers' digital competence, instructional design, digital objects and resources, assessment in technology-enhanced environments, mobile learning, video games, virtual worlds, Web 2.0, open science and open education, generative artificial intelligence, and gaps in access, use, and participation. This broad range of topics corresponds to the journal's declared scope, which structures its specialization around online learning, the educational integration of technologies, the acceptance and adoption of emerging technologies, and digital learning environments.

The thematic evolution of RELATEC reflects the shift within the field from an initial concern with the instrumental incorporation of technologies towards a more complex understanding of digital education. Special issues and monographic sections are particularly relevant indicators of this evolution. In 2016, a monographic issue on digital citizenship was published; in 2017, a special issue addressed the transition from textbooks to digital educational materials; in 2020, a monographic issue focused on Educational Technology research supported by mixed methods; in 2023, a monographic issue examined the lessons learned from an unprecedented educational experience in Ibero-America after the pandemic, together with a special section devoted to open science in educational research; and, in 2025, a monographic issue focused on open science and open education.

This evolution makes it possible to identify at least five major thematic stages in RELATEC's trajectory: (1) initial educational digitalization and e-learning: studies on ICT, virtual platforms, multimedia, educational software, and online didactic communication; (2) curricular and institutional integration of technologies: analyses of policies, plans, programmes, good practices, and teacher training; (3) learning environments and digital culture: learning communities, Web 2.0, learning objects, virtual worlds, online collaboration, and digital materials; (4) digital competence, inclusion, and citizenship: teacher education, the digital divide, digital citizenship, accessibility, inclusion, and critical uses of technology; and (5) open science, open education, and artificial intelligence: open resources, open data, citizen science, generative AI, the metaverse, analytics, adaptive learning, and new ethical challenges.

Since its first issue, the journal has explicitly defined itself as a diamond open access journal. This means that its articles are freely available online and may be read, downloaded, copied, distributed, printed, searched, and used for lawful purposes without economic, legal, or technical barriers other than those inherent to internet access. RELATEC's adoption of this model contributes to democratizing access to scientific knowledge in Educational Technology. It also protects the academic community from publishing models based on article processing charges (APCs), which may generate inequalities among researchers, institutions, and countries. The diamond route is particularly important for areas such as Education and the Social Sciences, where project funding and the availability of resources to pay APCs are unequal and often limited.

However, open science cannot be reduced to the free availability of articles. UNESCO defines open science as a set of principles and practices aimed at making scientific research accessible to all, within an inclusive, equitable, and sustainable knowledge production system. In this regard, RELATEC has incorporated policies that broaden its commitment: the Creative Commons Attribution 4.0 International licence, the promotion of self-archiving, the recommendation to deposit supplementary materials and research data in institutional or subject-specific repositories, the use of persistent identifiers, and an orientation towards transparency, replicability, and knowledge reuse. RELATEC's recent inclusion in the Diamond Discovery Hub of the European Diamond Capacity Hub further reinforces this orientation.

Journal quality is an essential feature of great value to editors, authors, and readers. Through its editorial policy, institutional continuity, and presence in evaluation and indexing systems, RELATEC has progressively consolidated the rigour of peer review, editorial transparency, ethical compliance, regularity, internationalization, visibility, impact, preservation, openness, professionalization of processes, and the trust of the scientific community. For example, the FECYT Seal of Quality is one of the most relevant forms of recognition for Spanish scientific journals, and RELATEC has renewed it since 2016. RELATEC also declares its adherence to ethical standards, principles of transparency, and the good practices of the Committee on Publication Ethics (COPE). In addition, the journal has developed a specific policy on gender equality and inclusion, including a commitment to a minimum representation of 40% women on editorial bodies and among reviewers, the recommendation to use inclusive language, and the full identification of authorship.

At the international level, RELATEC is included in Emerging Sources Citation Index (ESCI), DOAJ, ERIHPlus, MIAR, Dialnet, Latindex, REDIB, EBSCO, IRESIE, Dulcinea, Paperity, REDINED, and other scientific information, evaluation, and dissemination systems. Its presence in ESCI is particularly significant because it places the journal within the Web of Science Core Collection. Inclusion in Journal Citation Reports further broadens RELATEC's exposure to international bibliometric indicators. Nevertheless, the excellence of a diamond journal does not lie solely in competing within global metrics, but in demonstrating that it is possible to adopt a form of scholarly communication that is rigorous, open, public, international, and socially committed.

2. Presentation of the Special Section

The special section commemorating RELATEC's 25th anniversary seeks to provide a space for academic and scientific reflection on the evolution, tensions, and current challenges of Educational Technology. Coordinated by the guest editors Manuel Area-Moreira (University of La Laguna) and Bartolomé Rubia-Avi (University of Valladolid), the section brings together contributions by authors whose trajectories have played a decisive role in consolidating the field in Spain and Ibero-America over recent decades. Manuel Area represents one of the central voices in the construction of the field in recent decades (Area-Moreira et al., 2016, 2023). Bartolomé Rubia has made a sustained contribution to innovation, collaborative learning, and educational technologies (Rubia-Avi, 2022a, 2022b).

The selection of invited authors gives the section a high level of scientific and academic quality. Jesús Salinas has been principal investigator of the Educational Technology Group at the University of the Balearic Islands, director of the UIB Institute for Educational Research and Innovation, co-director of the Interuniversity Master's Degree in Educational Technology, and coordinator of the Doctoral Programme in Educational Technology (Salinas Ibáñez et al., 2017; Salinas Ibáñez & Marín Juarros, 2019). María Paz Prendes, Professor at the University of Murcia, has produced especially relevant work on digital competence, educational technology, teacher education, and innovation (Prendes, 2022; Prendes et al., 2018). Ana García-Valcárcel, Professor at the University of Salamanca, has a long-standing research trajectory linked to innovation and digital education (García-Valcárcel Muñoz-Repiso & Basilotta-Gómez-Pablos, 2017; García-Valcárcel Muñoz-Repiso & Caballero González, 2019). Adriana Gewerc, Professor at the University of Santiago de Compostela, has developed a critical line of work on educational technology, teacher education, digital culture, and professional identity (Gewerc-Barujel & Anguita-Martínez, 2025; Gewerc-Barujel & Ramos-Trasar, 2022). Mercè Gisbert, Professor of Educational Technology at Rovira i Virgili University, is an international reference in technologies applied to education, digital competence, and teacher education (Gisbert Cervera et al., 2016; Gisbert Cervera & Caena, 2022). María Luisa Zorrilla, professor and researcher at the Autonomous University of the State of Morelos (Mexico), promoted the creation of the UAEM Directorate of Multimodal Education and, in 2024, received recognition from Open Education Global for her contribution to open education and open educational resources (Zorrilla-Abascal, 2016; Zorrilla-Abascal & Castillo Díaz, 2023). In most cases, these articles have been written in co-authorship with outstanding teachers and researchers in the field of Educational Technology.

Manuel Area-Moreira's article, «*Theoretical Foundations for University Didactics with Generative Artificial Intelligence: The DIDACT.IA Model*», opens the section by reflecting on the need to construct a didactic theory for the educational use of generative artificial intelligence, one of the most urgent issues in contemporary higher education. Its contribution is particularly relevant because it moves the debate beyond instrumental uses, ethical risks, or merely technical literacy, and focuses instead on the pedagogical dimension of educational technology. The DIDACT.IA model organises the educational use of artificial intelligence (AI) into six steps: questioning, comparing, engaging in critical dialogue, verifying, personally reworking, and reflecting. Its central idea is that AI can support learning, provided that students maintain cognitive control of the process through critical thinking. This relevant contribution offers a conceptual framework in which AI is not understood as a replacement for intellectual work, but as a didactic mediation that requires design, judgement, authorship, verification, and responsibility.

The article by Jesús Salinas, Juan Moreno-García, and Jacoba Munar-Garau, «*Personalised Learning Supported by Digital Technologies: Trends, Challenges and Perspectives*», revisits a classic issue in Educational Technology that has gained renewed relevance with learning analytics, adaptive systems, and generative artificial intelligence. The article distinguishes between two major orientations of personalisation: one centred on technological adaptation through algorithms, analytics, and intelligent tutoring systems; and another linked to curricular flexibility, learner autonomy, flexible pathways, and co-design. Its main contribution lies in showing that personalisation should not be reduced to algorithmic automation or technical efficiency. Personalisation is a pedagogical phenomenon that requires human supervision, attention to equity, data protection, bias analysis, and consideration of the social dimension of learning.

The article by Ana García-Valcárcel Muñoz-Repiso, Marcos Cabezas-González, Sonia Casillas-Martín, and Verónica Basilotta Gómez-Pablos, «*Are Students Digitally Competent? Progress, Misalignments and Future Challenges*», offers a documentary review focused on the Ibero-American context and on students' digital competence over the last 25 years. The study shows that, although significant progress has been made, important misalignments persist, such as the predominance of research in higher education compared with compulsory education, the frequent use of self-perception-based instruments, dependence on European and international frameworks, and shortcomings in areas such as digital safety, content creation, critical evaluation of information, and academic uses of technologies. The article concludes that everyday familiarity with devices and platforms does not amount to critical, academic, and civic digital competence.

Adriana Gewerc, Uxía Regueira, and Angela González-Villa contribute to this Special Section with the article entitled *«Ibero-American Research in Educational Technology as a Vehicle for Official Recontextualisation (2019–2025): A Quantitative Study of Three Spanish Journals»*. Based on a corpus of 538 articles published in three Ibero-American journals indexed in the first quartile of Scopus, the study combines bibliometric analysis, semantic networks, methodological classification, and exploratory epistemological analysis. The results show a field organised into nine conceptual communities, with a predominance of quantitative methodologies, instrumental discourse, and an almost residual presence of theoretical production. The contribution is especially significant because it does not merely analyse which technologies are studied, but rather under what rules knowledge in Educational Technology is produced and legitimised. Drawing on Bernstein and Beigel, the authors interpret the field as an applied area with weak conceptual autonomy and strong formal regulation, opening a debate on academic dependence, imported discourses, platformisation, and limited critical density.

María Paz Prendes-Espinosa, Víctor González-Calatayud, and Nerea Gálvez-Vilar present «*Do Our University Students Perceive Themselves as Digital Entrepreneurs?*», a large-scale empirical study on the self-perception of digital entrepreneurship competence among final-year undergraduate students at Spanish public universities. The research is based on the «EmDigital» model and a sample of 4,100 students, using a quantitative, non-experimental, descriptive, and correlational design. The results indicate moderate-to-high levels of self-perception, with action planning receiving the highest rating and implementation and collaboration receiving the lowest scores, especially in relation to the real intention to undertake entrepreneurial initiatives. The article's specific contribution consists in conceiving digital entrepreneurship as a transversal competence for citizenship and employability, one that is not reduced to a merely business-oriented logic. The study concludes that students may perceive themselves as competent in declarative terms, but they need more authentic, collaborative, and action-oriented learning experiences in order to transform that self-perception into practical capacity.

The article by Roxana Rebolledo-Font de la Vall and Mercè Gisbert-Cervera, «*Creating Applications with AI to Teach English: Perceptions and Challenges in Initial Teacher Education*», addresses the ability to create with AI as an emerging dimension of artificial intelligence literacy. The study analyses the perceptions of 51 university students from three Chilean public universities who designed educational applications using Gemini 3.0. The results are organised around the pedagogical potential of AI for English language learning, the creation of resources and applications, the new role of teachers, the competences required, and the challenges involved in its use. Its contribution to knowledge in Educational Technology is twofold. On the one hand, it provides evidence on real practices of AI-based creation in initial teacher education; on the other, it shows that prompt formulation is not merely a technical skill, but a didactic competence, since translating a pedagogical intention into a precise instruction requires knowledge of content, learners, task design, and assessment criteria.

Finally, María Luisa Zorrilla-Abascal and Maribel Castillo-Díaz close the section with «*Hybrid Methods and E-Methods in Educational Research: An Analysis of Master's and Doctoral Theses*». The article analyses 19 postgraduate theses from the Institute of Educational Sciences of the Autonomous University of the State of Morelos (Mexico) that combine traditional methods and e-methods in face-to-face and digital contexts. The study identifies three types of methodological scenarios (natural, generated, and dual) and examines challenges related to participant access, privacy, consent, digital competences, control of the research setting, identity verification, and multimodal data analysis. This article offers a methodological contribution that is necessary for current educational research, as it shows that if educational practices no longer take place exclusively in face-to-face settings or exclusively in virtual environments, research designs must be able to capture this hybrid continuity without oversimplifying it.

3. Conclusion

RELATEC marks its 25th anniversary as a consolidated journal in the field of Educational Technology. The journal has contributed to the development of Educational Technology in the Ibero-American context. It has also defended an open model of scholarly communication, with no economic barriers for authors or readers, in line with the principles of open science, bibliodiversity, and diamond open access. It has likewise advanced in internationally recognised processes of editorial quality.

RELATEC's 25th anniversary coincides with a profound transformation of both scholarly communication and Educational Technology itself. Generative artificial intelligence is reshaping practices of teaching, learning, assessment, authorship, and peer review. Open science requires moving beyond general declarations towards verifiable policies on data, materials, licences, preservation, and methodological transparency. Diamond journals require stable institutional support, professional infrastructures, and specific recognition within academic evaluation systems.

In this context, RELATEC faces several strategic challenges. First, it must consolidate its internationalisation without relinquishing its Ibero-American, multilingual, and public identity. It must also strengthen the methodological quality of the works it publishes by promoting rigorous, transparent, and cumulative research. Another challenge is to advance towards more comprehensive open science policies, including FAIR data where possible, reusable materials, availability statements, and transparency practices. It is also important to reinforce the sustainability of the diamond model, making clear that the absence of costs for authors and readers does not imply the absence of editorial costs. Finally, RELATEC must promote responsible assessment, in which bibliometric indicators are interpreted as partial evidence rather than as substitutes for expert judgement.

RELATEC has favourable conditions to address these challenges. It has a consolidated trajectory, a recognisable scientific community, a coherent open access model, a presence in evaluation and indexing systems, and an editorial line specialised in a field of growing social relevance. The future has already begun to be written.

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ARTICLE / ARTÍCULO

Theoretical Foundations for Higher Education Pedagogy with Generative Artificial Intelligence (AI): The DIDACT.IA Model

Bases teóricas para una didáctica universitaria con la Inteligencia Artificial (IA) generativa. El modelo DIDACT.IA

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Abstract: Generative artificial intelligence (AI) in higher education is causing a pedagogical disruption that affects the meaning of academic tasks, assessment processes, teaching roles, and students' relationship with knowledge. Academic studies and publications have focused on describing instrumental uses, ethical risks, or digital competences, without sufficiently developing a didactic theory to guide the integration of AI into teaching and learning processes. This article aims to identify the theoretical foundations for university didactics with AI designed to foster the development of critical thinking. To this end, it adopts an integrative theoretical essay approach, bringing together contributions from distributed human-machine cognition, psychological and sociocultural approaches to critical thinking, and teaching theory. As a result, a conceptual framework is proposed for symbiotic learning, academic tasks as the instructional context of this interaction, and critical thinking as a condition for preserving students' epistemic agency. Finally, a didactic model, called DIDACT.IA, is presented, based on six dimensions: interrogation, comparison, critical dialogue, verification, personal reworking, and reflection. The article concludes that the model requires further empirical validation in different contexts of university teaching practice.

Keywords: Artificial Intelligence, Symbiotic Learning, Critical Thinking, Higher Education, Instructional Design, Academic Task.

Resumen: La inteligencia artificial (IA) generativa en la educación superior está provocando una disrupción pedagógica que afecta al sentido de las tareas académicas, a los procesos de evaluación, a las funciones docentes y a la relación del alumnado con el conocimiento. Los estudios y publicaciones académicas se han centrado en describir usos instrumentales, riesgos éticos o competencias digitales, sin desarrollar suficientemente una teoría didáctica que oriente la integración de la IA en los procesos de enseñanza y aprendizaje. Este artículo tiene como propósito identificar los fundamentos teóricos para una didáctica universitaria con IA orientada al desarrollo del pensamiento crítico. Para ello se adopta un enfoque de ensayo teórico de carácter integrador, articulando aportaciones de la cognición distribuida entre humano y máquina, los enfoques psicológicos y socioculturales del pensamiento crítico y la teoría de la enseñanza. Como resultado, se propone un marco conceptual para el aprendizaje simbiótico, las tareas académicas como contexto instruccional de dicha interacción, y el pensamiento crítico como condición para preservar la agencia epistémica del estudiante. Finalmente, se presenta un modelo didáctico, denominado «DIDACT.IA», basado en seis dimensiones: interrogación, comparación, diálogo crítico, verificación, reelaboración personal y reflexión. Se concluye que el mismo necesita mayor validación empírica en distintos contextos de la práctica docente universitaria.

Palabras-clave: Inteligencia Artificial, Aprendizaje Simbiótico, Pensamiento Crítico, Educación Superior, Diseño Instruccional, Tareas Académicas.

1. Introduction

In recent years, a large number of academic studies have been published on the impact, uses, opportunities, and risks of generative artificial intelligence (AI) in higher education (Crompton & Burke, 2023; Kasneci et al., 2023). In this regard, AI requires a reconsideration of several classic assumptions of university didactics: the relationship between information and knowledge, authorship in academic work, the nature of the task, the meaning of assessment, and the role of the teacher (Pérez-Gómez, 2024).

Current discourses oscillate between techno-pedagogical enthusiasm and moral alarm. In the first case, AI is presented as a resource for increasing efficiency, personalising learning, offering immediate feedback, supporting assessment, or automating certain teaching and administrative tasks (Lee et al., 2024; Xia et al., 2024; Francis et al., 2025). In the second, emphasis is placed on the risks of academic dishonesty, loss of authorship, the compromising of assessment validity, intellectual dependence, or impoverishment of critical thinking (Dawson et al., 2024; Kofinas et al., 2025; Bittle & El-Gayar, 2025). Both positions address troubling dimensions of the phenomenon, but they remain insufficient because they do not formulate a theory of teaching that establishes what learning should be promoted, through which tasks, with what forms of teacher mediation, according to which assessment criteria, and under what ethical principles in relation to AI.

The central problem addressed in this article is the absence of a sufficiently articulated didactic foundation to guide the use of AI in higher education from a critical, formative, and epistemologically grounded perspective. Its original contribution is to offer a theoretical framework that justifies a higher education pedagogical framework in the era of AI by integrating existing knowledge from different interdisciplinary fields whose shared concern is the primacy of the human subject in relation to machines, and by formulating practical prescriptions through the model called DIDACT.IA.

2. Approach and Method

This study takes the form of an integrative and purposeful theoretical essay. It does not present empirical research or the evaluation of a specific experience, but rather a proposal for theoretical articulation that makes it possible to explain and prescribe how AI may be incorporated into higher education teaching.

The starting point for this study can be found in an earlier work (Area-Moreira, 2025), in which a didactic model for critical thinking with AI was formulated on the basis of an analysis of real experiences in the context of university teaching (Area-Moreira & González-González, 2026). These works describe practical examples of how learning tasks and activities have been implemented by asking students to use AI tools according to the steps and dimensions of the model.

Building on these references, the procedure followed consisted of reviewing, selecting, and integrating contributions from different fields or traditions: human-machine interaction, instructional design, and psychological and sociocultural approaches to critical thinking. On the basis of this review, three axes were identified for constructing the proposal: the student as an epistemic agent through processes of symbiotic learning, the academic task as the central unit of didactic design, and critical thinking as the formative purpose of teaching with AI.

The bibliography used was selected according to three criteria: theoretical relevance for the axes of the model, the recency of the literature concerning generative AI and higher education, and each reference's capacity to support didactic implications regarding tasks, assessment, epistemic agency, and critical thinking. Integration was carried out through interpretive reading and conceptual comparison of the contributions, identifying convergences among pedagogical tradition, studies on human-machine interaction, and recent literature on educational AI.

Artificial intelligence tools were used in the preparation of this article with differentiated and complementary functions. ChatGPT was used to explore initial outlines of ideas, improve the wording, and review the formal suitability of the text in relation to the journal's requirements. Elicit and Perplexity were used to locate academic literature and obtain information from specialised databases. Notebook was used to organise sources and prepare content syntheses of the selected bibliography. In all cases, the contributions generated by these tools were reviewed, checked, and critically reworked, while the author retained intellectual responsibility for the selection of sources, the theoretical interpretation, and the final formulation of the didactic proposal.

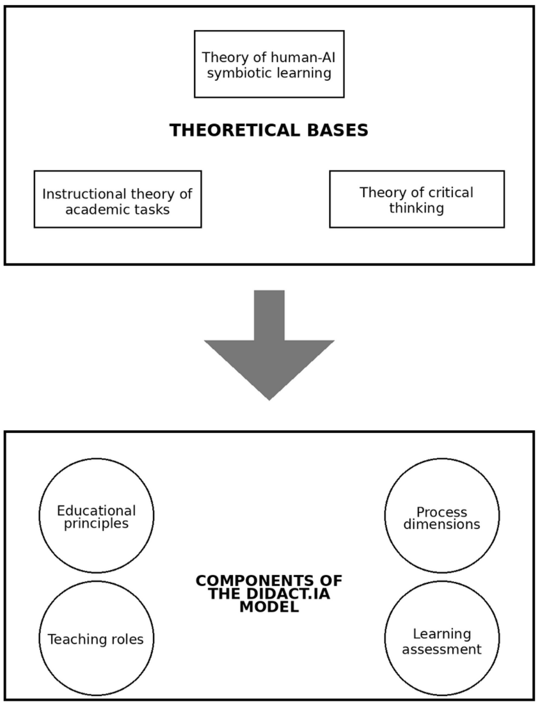

Figure 1. Theoretical bases and components for a didactics of teaching and learning with AI (DIDACT.IA Model).

This essay is organised into two parts or sections (see Figure 1). The first presents concepts drawn from the theoretical traditions of human-machine interaction, studies on critical thinking, and contributions from teaching theory.

The second part presents the translation of these theoretical developments into organised principles and dimensions for the design and development of didactic processes involving the use of AI in order to foster students' epistemic and critical capacity in relation to intelligent machines. This is the DIDACT.IA model.

3. Theoretical Foundations for Constructing a Didactics with AI

What are the theoretical references that justify and give meaning to a didactics with AI for students' critical thinking? The answer lies in the interrelation and integration of three approaches or fields of research and knowledge: cognitive symbiosis through human-machine interaction, the subject's critical thinking, and academic tasks as a learning context.

3.1. Theory of Human-AI Symbiotic Learning: The Student as Epistemic Agent

The symbiotic relationship between human beings and computers was proposed by Licklider (1960), who anticipated the possibility of close cooperation between human intelligence and computational systems, not oriented toward replacing the subject, but toward augmenting human capabilities to formulate problems, make decisions, and address complex situations. That foundational intuition has acquired renewed relevance today in the face of generative artificial intelligence, which is capable of producing answers, simulating dialogue, generating texts, and participating in processes of knowledge reworking.

From this perspective, generative AI cannot be understood solely as a passive tool that executes instructions, but rather as an artificial agent that intervenes in human cognitive activity. The concept of distributed cognition (Hutchins, 1995) indicates that cognition is not reduced to internal processes within an individual mind, but is distributed among subjects, artefacts, representations, languages, and activity environments.

The theory of the extended mind (Clark & Chalmers, 1998) suggests that certain external objects can be functionally integrated into a person's cognitive processes. A notebook, a calculator, a search engine, a database, or an AI system can act as external supports for memory, reasoning, representation, or symbolic production. What is decisive is not whether these artefacts are inside or outside the mind, but whether they participate significantly and functionally in a cognitive activity.

In this sense, AI can become an extension or amplification of the student's process of inquiry, analysis, writing, or revision. However, it acquires educational value only when the subject preserves the capacity to examine its responses critically, decide on their relevance, and assume final responsibility for the knowledge produced.

Likewise, 4E cognition approaches - embodied, embedded, enacted, and extended - conceive cognition as embodied, situated in material and social contexts, enacted through action, and extended through tools and artefacts (Newen, De Bruin, &

Gallagher, 2018). Learning with AI, from this position, does not mean passively receiving information generated by an algorithmic system, but participating in a situated activity in which the student interprets, decides, contrasts, reformulates, and produces knowledge in interaction with an artificial agent. Cognition emerges in the dynamic relationship among subject, tool, task, and context. Therefore, a didactics with AI should not focus only on the availability of intelligent applications for educational purposes, but on the design of learning situations that critically organise that relationship.

Another key concept is that of human epistemic agency (Coeckelbergh, 2026; Wu, Lee, Chai, & Tsai, 2025), understood as the subject's capacity to act responsibly in the construction, validation, and communication of knowledge. In contexts mediated by AI, epistemic agency is expressed in the student's capacity not to delegate to the machine the judgement of truth, relevance, or value of its responses, but to interrogate, contrast, verify, rework, and situate them within an ethical and academic framework of their own. It involves formulating relevant questions, selecting sources, justifying claims, recognising limits, revising beliefs, evaluating evidence, and assuming responsibility for what is stated.

Studies on an Epistemic Entanglement Framework (Samuel, 2026) also show that the use of AI in learning cannot be understood as a merely instrumental relationship, but rather as a form of epistemic entanglement in which practices of searching, validating, and producing knowledge are reconfigured between the learner and the machine. Vendrell and Johnston (2026), for their part, insist that AI must be integrated through pedagogical designs that preserve deliberation, verification, and critical reflection.

From my point of view, the concept that integrates all the preceding references is symbiotic learning, although it has not yet been sufficiently defined or used in the international literature. Morello and Chick (2025) have proposed Human-AI Symbiotic Theory as an approach to relations of functional interdependence between humans and AI systems in academic and research processes. Xie and Fang (2025) propose a symbiotic learning model for integrating AI into art and design education, highlighting collaboration between human creativity and algorithmic generation. Wu et al. (2025) likewise explicitly employ the notion of a symbiotic learning partnership to analyse how to preserve human epistemic agency in interaction with generative AI. Yang and Jiang (2024), in turn, have identified four key aspects for effective human-AI symbiosis: coexistence, evolution, asymmetry, and reciprocity.

In this essay, we define human-AI symbiotic learning as a process of knowledge construction in which the student interacts critically with intelligent systems in order to expand their possibilities for exploration, representation, contrast, production, and reflection, without delegating to the machine ultimate responsibility for judgement, understanding, and intellectual authorship. Symbiotic learning consists of regulated cognitive coupling in which AI acts as mediator, interlocutor, mirror, counterpoint, or cognitive prosthesis, while the student preserves and develops their epistemic agency. This idea comes close to the concept of hybrid intelligence or extended cognition, understood as the complementary combination of human and artificial intelligence to achieve outcomes superior to those that each could achieve separately (Dellermann, Ebel, Söllner, & Leimeister, 2019). It is also an assumption that connects with the hybrid human-AI learning technologies proposed by Molenaar (2022).

Consequently, a didactics with AI should aim for students to learn to establish symbiotic relationships with intelligent systems. This means teaching them to use the machine not as a substitute for intellectual effort nor as a device responsible for carrying out academic tasks, but as a means of expanding, analysing, contrasting, and problematising thought. In this regard, Pietarinen and Shi (2026) propose three guiding principles for students' use of AI: moral legitimacy (when AI influence enters the dark side of manipulation or deception), developmental integrity (how tools support, rather than replace, reflective judgement and imaginative work), and value preservation (protecting epistemic agency and intellectual virtues).

The DIDACT.IA model is grounded precisely in this conception. Its six dimensions - interrogation, comparison, critical dialogue, verification, personal reworking, and reflection - seek to turn interaction with AI into a valuable experience for developing students' competence as epistemic agents. The purpose is not for students to think less because they have a machine that produces answers, but for them to learn to think better by being compelled to formulate more precise questions, contrast arguments, identify biases, check evidence, reconstruct meanings, and reflect on their own learning process.

3.2. Theory of Critical Thinking and the Cognitive Processes Involved

The second foundation for a didactics with AI, closely linked to the concepts of epistemic agency and symbiotic learning, is critical thinking. Its importance goes back to the Greek philosophers as a basis for constructing the identity of the subject and the active citizen. In the current age of informational abundance and automated production of responses, educational value does not lie in accessing information, but in knowing how to question it, interpret it, evaluate it, and transform it into one's own knowledge.

Authors such as Ennis (1985), Paul and Elder (2006), Facione (1990), and Bailin (2002) have linked critical thinking to the capacity to make reasoned judgements, evaluate arguments, analyse evidence, identify assumptions, and act with a reflective disposition. From cognitive psychology, critical thinking is related to reasoning skills, problem solving, transfer, metacognition, and regulation of judgement. From sociocultural perspectives, critical thinking is not only an individual skill, but a practice situated in discourse communities, traversed by languages, norms, values, power relations, and shared criteria of validation. In this regard, it is necessary to recall the extensive bibliography of Paulo Freire on this matter.

In cognitive terms, critical thinking involves operations such as interpreting information, analysing argumentative structures, comparing perspectives, inferring consequences, evaluating evidence, detecting contradictions, identifying biases, formulating questions, justifying conclusions, and making reasoned decisions. In metacognitive terms, it requires monitoring one's own thinking process, recognising uncertainties, revising beliefs, distinguishing between understanding and repetition, and assessing the quality of one's own performance. In attitudinal terms, it requires intellectual openness, epistemic humility, willingness to doubt, honesty, perseverance, a search for evidence, and responsibility for the consequences of what is stated.

Generative AI can produce fluent, structured, and apparently sound responses, but it does not possess epistemic responsibility in the human sense. It may invent references, reproduce biases, homogenise perspectives, conceal uncertainties, or present arguments of different strength as if they were equivalent. For this reason, a didactics with AI cannot be limited to teaching "good prompts"; it must educate subjects capable of exercising critical judgement about the products of the machine.

Epistemic agency and critical thinking are complementary dimensions of learning: agency gives the student the responsibility and capacity to act as an epistemic subject, while critical thinking provides the cognitive and discursive tools needed to evaluate, justify, and transform knowledge rigorously.

In other words, critical thinking is what enables the student not to become alienated by the generative power of AI. Without critical thinking, the human-machine relationship tends to become one of dependence: the student requests, receives, copies, adapts superficially, and submits. With critical thinking, the relationship can become symbiotic learning: the student asks, contrasts, discusses, verifies, transforms, and assumes intellectual authorship of the outcome. Therefore, a didactics with AI must have as a permanent educational goal that students learn to develop critical thinking in their relationship with AI and with the products it generates.

Ultimately, critical thinking is what enables the student to maintain agency and cognitive autonomy in the symbiotic relationship with the machine. AI can generate information, suggest options, and produce texts, but it cannot judge, question, or assume responsibility for the knowledge it produces. It is the student who, through critical thinking, evaluates the quality of what AI generates, contrasts sources, detects biases, and constructs their own understanding. Critical thinking represents the most relevant formative goal of the DIDACT.IA model.

3.3. Instructional Theory: Academic Tasks

The third theoretical basis for a didactics with AI comes from theories of teaching and, specifically, from instructional design. The incorporation of AI does not eliminate the need to design teaching intentionally; on the contrary, it intensifies it. When students have access to tools capable of producing texts, solving problems, or generating explanations, the teacher must design tasks that cannot be reduced to the mere acquisition of an answer. The central didactic question ceases to be "what product should the student submit?" and becomes "what intellectual processes must the student activate in order to construct that product critically?"

The tradition of systemic instructional design, represented by authors such as Gagné, Merrill, Reigeluth, Romiszowski, and Bloom, provides valuable principles for this reconstruction. Gagné (1985) stressed the importance of organising the internal and external conditions of learning, sequencing instructional events, and attending to different types of outcomes. Bloom and his collaborators proposed a taxonomy of educational objectives that makes it possible to differentiate levels of cognitive complexity, from remembering and understanding to analysis, evaluation, and creation. Merrill (2002) formulated his first principles of instruction around the resolution of real problems, the activation of prior knowledge, demonstration, application, and integration. Reigeluth (1999) insisted on the need for instructional theories sensitive to the complexity of contexts, and Romiszowski (1981) provided criteria for relating objectives, strategies, media, and assessment.

However, for a didactics with AI, Walter Doyle's (1983) concept of the academic task is especially relevant. Doyle conceived tasks as central structures of classroom life that organise academic work, define expected products, regulate cognitive operations, and condition the way students process content. Doyle and Carter (1984) described a task as including, among other elements, a final product, available resources, operations to be carried out, and assessment conditions. They also pointed out that tasks are embedded in systems of risk, ambiguity, and valuation, so that students learn not only content, but also ways of interpreting what counts as legitimate and successful work in the classroom.

If a task is limited to requesting a generic essay, a documentary synthesis, or an explanatory response, the student can delegate much of the process to an AI system. But if the task requires the student to formulate their own questions, compare responses from different systems, justify decisions, verify sources, document the process, rework the outcome in their own voice, and reflect on errors and biases, then AI ceases to be a shortcut and becomes an object of cognitive work.

The academic task should be considered the central axis of instructional design with AI because it provides a situational ecology for learning. It articulates content, goals, resources, interactions, quality criteria, products, and assessment processes. There is no critical learning with AI unless there are carefully designed tasks that compel students to make their thinking visible.

Different types of academic tasks with AI can be distinguished: a) exploration tasks, aimed at formulating questions, delimiting problems, and generating hypotheses; b) comparison tasks, focused on contrasting responses from different tools or models; c) verification tasks, aimed at checking accuracy, currency, biases, and evidence; d) production tasks, oriented toward producing texts, projects, designs, or solutions with AI support; e) argumentation tasks, centred on defending one's own position against alternatives; f) metacognitive tasks, aimed at reconstructing the process followed, identifying decisions, and assessing learning; and g) ethical tasks, oriented toward analysing social implications, authorship, transparency, privacy, and justice.

The minimum components of an academic task with AI should include: formative purpose, initial problem or situation, expected product, documented process, permitted tools, criteria for ethical use, sources for contrast, expected cognitive operations, evidence of the process, assessment criteria, and final reflection. From this perspective, a didactics with AI must propose complex, rich, and varied tasks so that students activate processes of analysis, comparison, inference, argumentation, judgement, creation, and self-regulation, while being required to provide evidence of these processes.

This conceptualisation of the academic task can also be enriched by activity theory, which makes it possible to understand the task not as an isolated instruction, but as part of an activity system composed of subjects, objects, instruments, rules, community, and division of labour (Engeström & Sannino, 2021). From this sociocultural perspective, academic tasks mediated by AI configure an ecology of activity in which student, teacher, algorithmic tool, assessment criteria, and disciplinary culture interact. Along similar lines, the Activity-Centred Analysis and Design (ACAD) approach emphasises that design for learning does not directly prescribe what

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students learn, but configures tasks, resources, spaces, and relationships to foster valuable activities (Goodyear, Carvalho, & Yeoman, 2021).

4. The DIDACT.IA Model

A didactics with AI must respond to at least four questions: what educational principles should guide its use; what instructional methods and strategies make it possible to activate valuable learning; how the process, and not only the product, should be assessed; and what teaching roles emerge in this new scenario. These questions make it possible to shift the focus from technology to teaching, from the tool to the task, and from automation to the formation of judgement.

4.1. The Educational Principles of the DIDACT.IA Model

University didactics with AI should be grounded in a set of principles derived from the theories discussed above, which can be specified in the following ideas:

- Centrality of human agency. AI must be at the service of learning and must not replace the student's cognitive responsibility. Every use of AI should strengthen students' capacity to decide, argue, verify, and produce their own knowledge.

- Critical thinking. The learning objective is not to generate formally correct products, but to promote understanding, analysis, transfer, and critical judgement.

- Transparency and traceability. Students must declare what tools they have used, for what purpose, what instructions they formulated, what responses they obtained, and how they transformed them.

- Epistemological verification. No AI-generated product should be assumed to be valid without contrast with academic sources, data, evidence, or expert criteria.

- Responsible authorship. The final production must express the student's understanding, position, and voice. AI may collaborate in the process, but it must not replace intellectual authorship.

- Ethics and justice. The use of AI must consider bias, privacy, intellectual property, accessibility, sustainability, and social effects.

- Metacognition. Learning with AI requires reflection on how learning took place, what decisions were made, what errors appeared, and what limitations the tool had.

These principles make it possible to avoid two forms of reductionism: prohibitionism, which ignores the cultural transformation produced by AI, and technological solutionism, which naively trusts in the tool's capacity to improve education automatically.

4.2. Instructional Strategies: Dimensions of the Model

The didactic strategy consists of designing academic tasks that require students to interact critically with AI. To this end, the teacher must plan situations in which the tool is not a shortcut, but an object of analysis, contrast, and reworking. Examples of tasks would include: analysing a scientific controversy by comparing responses from several AI systems; producing a critical essay by verifying the claims generated by the machine; designing a didactic proposal by contrasting AI suggestions with academic literature; reviewing biases in explanations produced by different systems; or constructing one's own argumentation on the basis of a sustained dialogue with AI. For example, in a university course, students might ask two AI systems for an explanation of a complex concept, compare both responses, identify omissions or errors, contrast them with academic sources, rework their own synthesis, and submit a brief metacognitive report on the decisions taken. In another task, they might ask AI for arguments for and against an educational controversy, verify the solidity of the cited sources, and finally construct a justified personal position.

The DIDACT.IA model starts from the premise that the educational use of AI should be oriented toward the development of critical thinking through complex academic tasks in which students interact with intelligent systems while retaining responsibility for the knowledge process. This process of student-AI interaction in each academic task should be organised around six process dimensions: interrogation, comparison, critical dialogue, verification, personal reworking, and reflection. These dimensions should not be understood as rigid steps, but as recurrent actions that can be flexibly combined according to the nature of the task (see Figure 2).

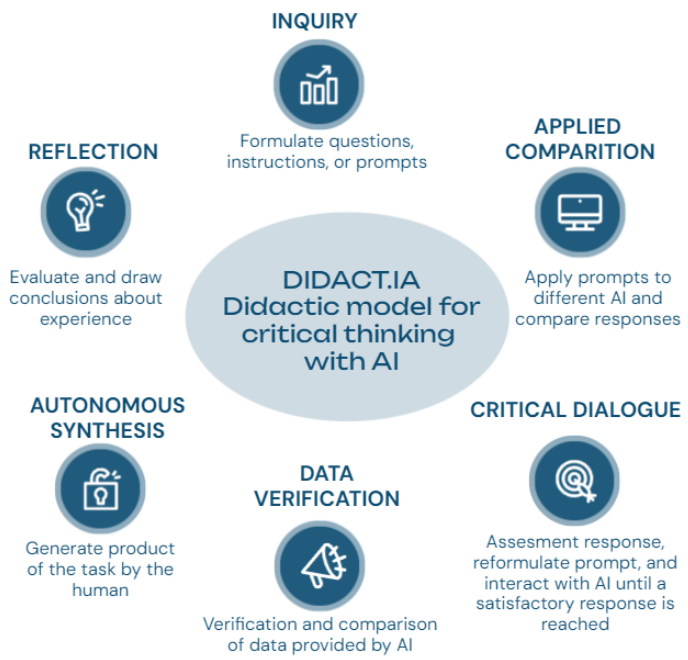

Figure 2. Didactic model for critical thinking with AI (Area-Moreira, 2025).

1) Inquiry. The student learns to formulate relevant, precise, and open questions. It is not merely a matter of writing effective prompts, but of transforming a need for knowledge into an intellectually meaningful request. Interrogation involves delimiting the problem, making the context explicit, requesting criteria, asking for alternatives, and anticipating possible biases.
2) Comparison. Students contrast responses generated by different tools, by different prompts, or by academic sources. Comparison makes it possible to detect differences in approach, omissions, errors, biases, and levels of depth. This dimension activates analysis, classification, discrimination, and judgement.
3) Critical dialogue. The student does not passively accept the first response, but engages in dialogue with AI: asking for clarification, questioning claims, requesting evidence, introducing counterarguments, and reformulating instructions. Critical dialogue turns interaction into an iterative process of refinement.
4) Verification. Every response must be checked against reliable sources. Verification involves seeking evidence, checking data, reviewing references, distinguishing facts from interpretations, and evaluating the quality of sources. It is an essential dimension for avoiding epistemic dependence on the machine.
5) Autonomous synthesis. The student reconstructs knowledge in their own words, structure, and position. They do not merely edit an AI-generated text, but integrate contributions, discard errors, reorganise ideas, and produce a discourse of their own.
6) Reflection. Finally, students analyse the process followed: what they learned, how their understanding changed, what AI contributed, what limitations they encountered, what decisions they made, and how they would evaluate the quality of their own work. This dimension activates metacognition and ethical awareness.

These six dimensions make it possible to transform the use of AI into a formative practice oriented toward critical thinking. AI ceases to be a source of answers and becomes a problematic interlocutor that demands judgement, control, and responsibility.

4.3. Assessment of Learning: Assessing Processes, Not Only Products

Generative artificial intelligence requires a reconsideration of learning assessment. For decades, many assessment practices have relied on the assumption that the product submitted by the student - an essay, a report, a problem solution, a programme, an exam, a presentation, or a documentary synthesis - expressed with reasonable fidelity their knowledge, capacities, and intellectual effort. However, when such products can be generated, corrected, expanded, or stylistically improved by AI systems, the relationship between final production and real learning becomes more fragile. The question is not merely to determine whether or not students have used an AI tool, but to ask what evidence makes it possible to assess whether they have understood, contrasted, decided, reworked, and responsibly assumed the knowledge they present.

The assessment proposed by the DIDACT.IA model should attend to at least three complementary planes. The first is the product, which remains important and should be assessed according to its conceptual rigour, argumentative coherence, expressive quality, appropriate use of evidence, suitability to purpose, and originality in the construction of discourse. The second is the process, understood as the set of actions through which the student has interacted with AI: initial interrogation, comparison of responses, critical dialogue, verification of information, revision of drafts, and reworking decisions. The third is metacognition, that is, the student's capacity to explain what they have learned, how they learned it, what role AI played, what limitations they detected in its responses, and what criteria they used to accept, reject, or transform its contributions.

This metacognitive dimension is especially relevant in interaction with generative systems. Tankelevitch et al. (2024) have pointed out that AI imposes new metacognitive demands on users, who must constantly monitor and regulate the quality of instructions, the reliability of outputs, and the degree of dependence on the tool. Translated into higher education, this means that assessing learning with AI also involves assessing students' capacity to exercise control over their own thinking: recognising uncertainties, detecting biases, identifying insufficiencies in generated responses, revising their decisions, and calibrating the trust placed in the machine.

This perspective coincides with recent proposals calling for more transparent and graduated frameworks for integrating AI into assessment. Perkins et al. (2024), through the Artificial Intelligence Assessment Scale, propose differentiating levels of permitted AI use according to the intended learning outcomes, avoiding both indiscriminate prohibition and uncritical acceptance. This logic is consistent with DIDACT.IA: in some tasks it may be pedagogically necessary to limit the use of AI; in others, to incorporate it explicitly as an object of analysis; and in others, to allow it as support for production, provided that evidence of process and intellectual responsibility is required.

In synthesis, the DIDACT.IA model proposes assessing not only what the student submits, but also the reconstruction of the process followed in producing it and the reflection on that experience. The central assessment question ceases to be whether the student "has used AI" and is instead formulated in more pedagogical terms: "How has AI been used? For what purpose? According to what criteria? What has been contrasted? What has been corrected? What has been reworked? What has the student learned about the content and about their own way of thinking?" Only when assessment incorporates these questions can it become a practice consistent with a didactics oriented toward critical thinking in the age of artificial intelligence.

4.4. The Role or Functions of Teachers in the Face of AI

It is evident that teacher professionalism must also be redefined in the face of AI. UNESCO (2024) has underlined this orientation by proposing an AI competency framework for teachers organised around a human-centred mindset, AI ethics, AI foundations and applications, AI pedagogy, and professional development. Along these lines, Chan (2024) warns that generative AI should not be conceived as a substitute for teachers, but as a technology with which educators must coexist and collaborate, while preserving those specifically human qualities linked to judgement, creativity, contextual sensitivity, and the educational relationship.

This transformation requires new forms of teacher professional development and competence. It is not enough to train teachers in the technical use of AI applications or in the writing of instructions or prompts. It is necessary to promote an expanded pedagogical competence that integrates technological understanding, didactic judgement, ethical sensitivity, and capacity for curricular redesign. The review by Tan et al. (2025) shows precisely that teachers' educational use of AI is closely linked to their training opportunities, professional needs, and the institutional conditions that favour or limit its pedagogical integration. The decisive question is not whether the teacher knows how to use a specific tool, but whether they have criteria for deciding when, how, for what purpose, and within what limits it should be incorporated into teaching.

The teaching role in relation to AI also has an indispensable ethical dimension. Teachers must establish clear frameworks for transparency, authorship, privacy, equity, and responsible use. They must also help students understand that uncritically delegating intellectual work to a machine is not only a problem of academic integrity, but also a renunciation of one's own epistemic agency.

It should also be noted that proposals are being developed that update the TPACK model in order to incorporate the specificity of AI into teachers' professional knowledge, such as AI-TPACK (Karataş & Ataç, 2025), HCAP (Chiu, 2026), or AIA-PCEK (Mimoudi & Mokhtari, 2025). These contributions are valuable because they situate AI within teachers' technological, pedagogical, disciplinary, ethical, and competence-related knowledge. However, DIDACT.IA differs from them in that its main object is not to describe the professional teaching knowledge required to teach with AI, but to propose a didactic architecture centred on student activity and on the sequence of operations that make it possible to transform interaction with AI into critical thinking and epistemic agency: interrogating, comparing, engaging in critical dialogue, verifying, reworking, and reflecting.

Ultimately, AI does not necessarily impoverish the teaching function, but it does render obsolete a conception of teaching based on the mere transmission of information and the assessment of closed products. Teacher professionalism is thus redefined as a practice of design, mediation, assessment, and ethical guidance aimed at enabling students to learn to think with AI, against AI when necessary, and always beyond it.

5. Conclusions and Practical Implications

Generative artificial intelligence is modifying the cultural, cognitive, and pedagogical conditions of higher education. Its presence requires a reconsideration of university didactics because it transforms the relationship among student, knowledge, task, assessment, and teaching. This article has argued that a didactics with AI cannot be limited to regulating the instrumental use of a new technology, but must be built on a pedagogical foundation capable of guiding its integration into teaching-learning processes. To this end, three theoretical axes have been proposed: human-machine interaction understood as symbiotic learning, instructional design centred on academic tasks, and critical thinking as both a formative goal and a condition of students' epistemic agency.

Symbiotic learning makes it possible to understand that AI can expand students' cognitive capacities provided that they retain critical control over the process. The academic task constitutes the central unit of didactic design because it organises intellectual activity, defines expected products, regulates cognitive operations, and establishes assessment conditions. Critical thinking, for its part, acts as a formative axis because it enables students not to become subordinated to the apparent cognitive authority of the machine. In this sense, the educational use of AI should not be oriented toward reducing intellectual effort, but toward enriching it, problematising it, enhancing metacognitive awareness..

In the DIDACT.IA model, the aim is for the student to become an epistemic agent capable of directing their interaction with AI. The student interrogates it, compares it, engages in critical dialogue with it, verifies its responses, personally reworks its contributions, and subjects the entire process to reflection. These six dimensions offer a structure for designing university tasks in which AI is not used as an easy solution to academic demands, but as a supporting technology for developing complex cognitive and metacognitive processes. Understood in this way, AI does not replace students' intellectual activity, but becomes a means of expanding it, contrasting it, and subjecting it to examination.

The practical implications of this approach are relevant for university teaching. First, it requires a revision of the design of academic tasks, avoiding activities that can be easily delegated to AI and promoting proposals that require inquiry, contrast, argumentation, decision-making, personal reworking, and metacognitive reflection. Second, it implies transforming assessment by shifting the emphasis from the final product to the process of knowledge construction. Assessing in AI-mediated contexts entails attending to the questions formulated, the prompts used, the responses obtained, the sources contrasted, the decisions to modify, and the critical awareness that the student develops regarding their own learning. Third, it calls for a redefinition of the teaching role: teachers must act as designers of learning ecologies, epistemological mediators, guides of human-AI dialogue, assessors of processes, and ethical guarantors of the academic use of these technologies.

The DIDACT.IA model also has institutional implications. Universities need to develop clear guidelines on the use of AI in teaching, not only from the perspective of academic integrity, but also from that of curricular innovation, formative assessment, and the development of students' critical competence. Course syllabi should explicitly state when, how, and for what purpose AI may be used, what evidence of the process must be provided, and what criteria will be used to assess authorship, transparency, and the quality of learning. Likewise, teacher training must go beyond the technical learning of tools and focus on didactic design, pedagogical mediation, process assessment, and ethical reflection on artificial intelligence.

The main limitation of this work is its theoretical nature. Although the model has been implemented in some university teaching situations, empirical research will be necessary to analyse the application of the DIDACT.IA model in different disciplines, degree programmes, and levels of student experience, as well as to evaluate its effects on the development of critical thinking, intellectual autonomy, and epistemic agency. This is the purpose of the research project PID2024-157674NB-I00, currently under development, from which this article derives. It will also be necessary to study how forms of human-AI interaction vary according to the type of task, the tool used, academic culture, assessment criteria, and university contexts. Similarly, future research should explore teachers' and students' perceptions of the model's feasibility, the difficulties of its implementation, and its possible adaptations to face-to-face, hybrid, and virtual environments.

In short, the framework proposed by the DIDACT.IA model offers a solid conceptual basis for advancing toward a university didactics capable of responding to the disruption generated by AI without renouncing the deepest purpose of higher education: to educate subjects capable of thinking, judging, creating, and acting autonomously and critically in relation to knowledge.

6. Acknowledgment

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ARTICLE / ARTÍCULO

Ibero-American research into Educational Technology as a vehicle for official recontextualisation (2019–2025). A quantitative study of three Spanish journals

La investigación Iberoamericana en Tecnología Educativa como vehículo de recontextualización oficial (2019-2025). Estudio cuantitativo en tres revistas españolas

Adriana Gewerc Barujel, Uxia Regueira & Angela González-Villa

Abstract: This quantitative study examines the structure of an Ibero-American academic research field on Education Technology, based on a corpus of 538 articles published in three regional journals indexed in the first quartile of Scopus —PIXEL-BIT, RIED and Educación XX1— between 2019 and 2026. The theoretical framework combines Basil Bernstein's theory of the pedagogic device —distribution, recontextualization (ORF and PRF) and evaluation rules, together with the concepts of classification, framing and vertical discourse— with Fernanda Beigel's concept of segmented academic circuits and the Ibero-American critical perspective on educational platformization. A multi-method design is proposed combining bibliometric analysis, semantic co-occurrence network analysis of keywords with community detection via the Louvain algorithm, rule-based lexical classification of methodological and discursive orientation applied to abstracts, and exploratory epistemological analysis using unsupervised clustering (K-Means) and Bernsteinian lexical classifiers. Results show a field with 9 conceptual communities articulated around a single hub-bridge (higher education), a markedly quantitative methodological distribution (60.8%) and instrumental discourse (61.7%), with marginal presence of critical traditions (5.3%) and almost total absence of theoretical production (0.5%). The emergence of generative artificial intelligence between 2024 and 2026 reorganizes the vocabulary and densifies the network without altering the recontextualizing structure or the formal grammar of the circuit.

Keywords: Educational Technology, Semantic Network Analysis, Pedagogic Device, Recontextualization, Academic Circuits, Generative Artificial Intelligence.

Resumen: Este estudio analiza desde una perspectiva cuantitativa la estructura del campo de investigación en Tecnología Educativa partir de un corpus de 538 artículos publicados en tres revistas iberoamericanas indexadas en el primer cuartil de Scopus —PIXEL-BIT, RIED y Educación XX1— entre 2019 y 2025. El marco teórico articula la teoría del dispositivo pedagógico de Basil Bernstein —reglas de distribución, recontextualización (ORF y PRF) y evaluación, junto con los conceptos de clasificación, enmarcación y discurso vertical— con el concepto de circuitos académicos segmentados de Fernanda Beigel y la perspectiva crítica iberoamericana sobre plataformización educativa. Se propone un diseño multimétodo que combina análisis bibliométrico, análisis de redes semánticas de co-ocurrencia de palabras clave con detección de comunidades mediante el algoritmo de Louvain, clasificación metodológica y discursiva mediante clasificadores léxicos basados en reglas aplicados sobre resúmenes y análisis epistemológico exploratorio mediante agrupamiento no supervisado (K-Means) y clasificadores bernsteinianos. Los resultados muestran un campo con 9 comunidades conceptuales articuladas en torno a un hub-puente único (educación superior), una distribución metodológica marcadamente cuantitativa (60,8%) y discursivamente instrumental (61,7%), con presencia marginal de tradiciones críticas (5,3%) y ausencia prácticamente total de producción teórica (0,5%). La irrupción de la inteligencia artificial generativa entre 2024 y 2025 reorganiza el vocabulario y densifica la red sin alterar la estructura recontextualizadora ni la gramática formal del circuito.

Palabras-clave:, Tecnología Educativa, Análisis de redes semánticas, Dispositivo pedagógico, Recontextualización, Circuitos académicos, Inteligencia Artificial Generativa.

1. Introduction

In recent decades, Educational Technology (ET) has grown remarkably in terms of both the volume of scientific output and its institutional presence, to become a well-established field within the educational sciences. This growth has intensified considerably since the onset of the COVID-19 pandemic, with education systems undergoing mass digitalisation, and the widespread adoption of virtual environments, digital platforms and, more recently, generative artificial intelligence (GenAI) (Bozkurt et al., 2024). However, this quantitative expansion has not been matched by sufficient problematization on the structure of the field itself. Various studies in recent years have consistently characterised the ET field as fragmented (Lai & Bower, 2019) with a marked emphasis on quantification (Baydas et al., 2015) and heavily influenced by concerns regarding practical design, to the detriment of a solid theoretical foundation (Zawacki-Richter et al., 2019). This lack of theoretical commitment appears to be a structural trend within the field: Hew et al. (2019) found that, of 503 articles analysed, only 35% had a solid theoretical framework, while more than 40% lacked one entirely.

In this context, Hannon and Al-Mahmood (2014) identify four major trends shaping research in educational technology: a) a focus on practical implementation centred on identifying ‘what works’ with insufficient attention paid to the structural, cultural and political conditions surrounding educational technology (Castañeda et al., 2020); b) the rise of learning analytics and the big data paradigm, which prioritise detecting patterns in large volumes of data, often at the expense of robust interpretative frameworks; c) the persistence of instructional design as the dominant tradition, rooted in positivist approaches; and d) innovation-oriented research, frequently criticised for its weak theoretical grounding. Similarly, Baydas et al. (2015) highlight the predominance of studies focusing on online learning environments and samples of university students.

The pressure to produce applicable, visible and immediately transferable results, coupled with the growing prominence of impact indicators, has favoured research focused on implementing and evaluating technologies in specific contexts. This has come at the expense of critical, theoretically informed or systemic approaches (Biesta et al., 2019; Lai & Bower, 2019). Added to this is the influence of a technology market that steers agendas towards commercial interests and reinforces technocentric discourses (Castañeda et al., 2020).

Against this backdrop, it is necessary to identify not only what Educational Technology researches, but also to question the conditions under which this knowledge is produced: What kind of knowledge does it produce? Under what rules is it accepted and circulated? What relationship does it have with frameworks imported from adjacent disciplines or supranational agencies? What scope does it allow for critical problematization?

1.1. Rules governing the production and circulation of knowledge in Educational Technology

The theory developed by Bernstein (1990, 2000), and recently revised by Barrett (2024) and Maldonado-Díaz (2022) in Spanish, offers a particularly productive conceptual framework for addressing the above questions regarding the production and circulation of knowledge in ET. Its categories — pedagogical device, recontextualization, classification, framing and vertical discourse — enable us to analyse not only what a field says, but also the rules that determine what can be said. From this perspective, pedagogical discourse does not produce original knowledge, but rather takes knowledge produced in other fields - the intellectual field of discourse production - and transforms it through a specific process termed 'recontextualization' by Bernstein (Bernstein, 1990). This process is overseen by two distinct fields: the field of official recontextualization (ORF), which encompasses state and supranational agencies, and the field of pedagogical recontextualization (PRF), which includes professional and academic spaces such as faculties of education and specialist journals. In recent decades, several authors have documented the process by which the ORF has colonised the PRF: generic frameworks of competence, quality, and effectiveness are gradually replacing the traditional disciplinary discourses that underpin educational fields (Apple, 2019; Maton, 2014; Singh, 2002).

Furthermore, the concepts of classification and framing allow us to describe how this mechanism is realised in specific practices (Bernstein, 1971, 2000). Classification denotes the strength of the boundaries between categories, such as disciplines, content and agents. When classification is strong (+C), the boundaries are actively maintained, whereas when it is weak (–C), they become blurred. Framing refers to control over the selection, organisation, sequencing, and evaluation of pedagogical communication. +F indicates strong control (in the classroom, the teacher controls everything; in the academic field, there is strict adherence to the validation paper canon), while –F indicates weak control (in the classroom, there are invisible pedagogies; in the academic field, there are diverse formats, such as essays, autoethnographies, and investigative narratives).

Distinguishing between vertical and horizontal discourse, and between hierarchical structures (Bernstein, 1999), allows us to classify the modes of organisation of knowledge. Bernstein (2000) proposes a typology of vertical discourse comprising four modes: disciplinary singulars, applied regions, generic discourses of the ORF, and critical traditions. Educational technology is a region by its very nature: it articulates knowledge drawn from various singulars and is oriented towards a field of practice.

Furthermore, the concepts of classification and framing allow us to describe how pedagogical and academic practices are regulated. A high level of framing, for example, is evident in strict adherence to the standardised format of the scientific article.

This brings us to the concept of the validation paper, referring to the IMRaD format. This historically established genre (Bazerman, 1988; Latour & Woolgar, 1986) acts as a regulatory mechanism, defining which claims are legitimate and under what conditions. In the current context, its adoption has become virtually mandatory in indexed journals, operating as a mechanism for validating knowledge and authorship.

All recontextualization takes place within a social space for the circulation of knowledge with its own geography, hierarchies, and asymmetries. Fernanda Beigel (2014) distinguishes four types of circuit within the global academic system: (i) international mainstream circuits supported by major publishing houses such as Elsevier, Springer and Taylor & Francis (indexed in Web of Science and Scopus); (ii) transnational open-access circuits; (iii) regional circuits in the Global South such as

Latindex, SciELO, Redalyc and CLACSO; and (iv) national circuits based on local publications. This segmentation is not horizontal; rather, it constitutes an unequal, hierarchical structure in which the mainstream's evaluation criteria tend to dominate regional academic circles through mechanisms such as indexing, impact factors, and university rankings (Beigel, 2014). Academic dependency is the concept that describes this structural asymmetry between peripheral producers of knowledge and the theoretical and methodological frameworks produced in centres (Beigel & Persia, 2024; Beigel & Sabea, 2014). Within this framework, the recontextualization of Educational Technology occurs in a space regulated by two factors: the internal logic of the pedagogical system and the external dynamics of global academic assessment.

1.2. Research in ET and the Recontextualization of the Field

The application of this theoretical framework to educational technology has given rise to a significant body of critical literature, particularly in the context of digital platforms and generative artificial intelligence. Williamson (2024) and Williamson et al. (2023) have demonstrated that the celebratory discourse surrounding digital transformation, and more recently AI in education, functions as a generic ORF discourse imported from technology industries and supranational bodies. This discourse colonises the pedagogical field. Selwyn (2024) has emphasised the epistemological and political limitations of AI in education, cautioning against the dominance of the datafication paradigm in modern education systems. Recent work by Pangrazio et al. (2023) on data infrastructures in schools and contributions to the Critical EdTech Studies volume by Komljenovic et al. (2025) point in the same direction: digitalisation is not merely the aggregation of technologies, but a mechanism, and European competence frameworks are central to this mechanism. In Latin American contexts, Dussel (2020) has demonstrated how pandemic-driven digitalisation has reshaped schools in favour of private platforms. Neut et al. (2024) and Miño-Puigcercós et al. (2026) highlight the normalisation of platform monoculture and the loss of pedagogical sovereignty as key concerns in the context of corporate platformization. Bozkurt et al. (2024) and the RIED special issue (2025) have documented the critical risks that AI poses to the pedagogical framework, such as uncritical dependence and algorithmic biases.

However, these categories have not yet been systematically analysed in the context of the Ibero-American research field on Educational Technology. There remains a lack of studies that integrate empirical analysis with a structural understanding capable of accounting for the organisation, regulation, and legitimisation of knowledge dynamics. This research addresses this gap and aims to answer the following question: How is the Ibero-American Educational Technology research field structured, and how does that structure evolve across the three techno-pedagogical waves that run through it between 2019 and 2025? This general question has been broken down into four specific questions, which are set out in Table 1.

2. Method

We propose a multi-method design that combines a mixed bibliometric approach with performance analysis and scientific mapping (Donthu et al., 2021), as well as computational content analysis and exploratory epistemological analysis. A corpus of high-impact scientific publications in the field of educational sciences with an Ibero-American scope is used to apply four sequential and interlinked phases of analysis

(Table 1). Each phase incorporates the information produced in the previous one, allowing the field to be approached from different, complementary perspectives.

Table 1. Study design: phases, research questions and techniques used

Phase	Research question	Technique / procedure	Input / output data
PH1	Who produces, where, and on what topics?	Descriptive bibliometric analysis: temporal distribution, geographical affiliation, international collaboration, frequency of normalised keywords	Input: metadata (year, authors, countries, keywords). Output: distribution tables, collaboration indicators, term frequencies
PH2	What are the conceptual trends in the field and how do they evolve over the period?	Semantic networks of keyword co-occurrence; centrality metrics (degree, betweenness, eigenvector); Louvain (Q) community detection; networks by time period	Input: normalised keywords (frequency ≥5; edge weight ≥2). Output: global network (66 nodes, 140 edges), 9 communities, centrality metrics per term
PH3	How is the field investigated methodologically, and from which discursive perspective?	Rule-based lexical classifiers applied to abstracts: (a) methodological classifier (6 categories); (b) discursive classifier (4 perspectives); (c) NMF topic modelling (6 latent themes)	Input: text of the abstract. Output: 'method' and 'discourse' labels for each article; global and temporal distributions
PH4	How does the field relate to external conceptual frameworks? (exploratory)	K-Means clusters (k=9) based on TF-IDF of keywords; Bernsteinian lexical classifiers applied to abstracts; validation using full text (n=27 articles, 3 per cluster)	Input: keywords (TF-IDF) + abstracts. Output: 9 thematic clusters, estimated epistemological profile, percentages of automatic/manual agreement per cluster

2.1. Corpus

The corpus consists of 538 articles published between 2019 and 2025 in three Spanish education journals ranked in the first quartile of the JCR: RIED-Revista Iberoamericana de Educación a Distancia (n=177), Educación XX1 (n=183) and Pixel-Bit. Revista de Medios y Educación (n = 186) from which eight online articles scheduled for publication in 2026 have been excluded.

The journal data were extracted manually by the research team. For each article, the following information was recorded: identification code; title; year; authors; country of affiliation per author; keywords in Spanish and English; and abstract. The full text was renamed using the assigned code and stored.

2.2. Analysis

The analysis is organised into four sequential and complementary phases (see Table 1). Phase 1 focuses on the descriptive bibliometric aspects of performance analysis (Donthu et al., 2021), including output, authorship, and geographical distribution. Phase 2 involves constructing and analysing a semantic network of keyword co-occurrence to identify the conceptual structure of the field and its thematic communities. Phase 3 classifies each article according to its methodological and discursive orientation using lexical classifiers applied to the abstracts. Phase 4 is exploratory in nature and examines the epistemological orientation of the field through independent thematic clusters and Bernsteinian classifiers.

All computational analyses were carried out in Python with the help of generative AI tools, namely Claude (Anthropic) and GitHub Copilot (OpenAI). The results were systematically cross-checked against each other and the reference literature. The research team was responsible for all methodological decisions and disciplinary interpretation (Bayram et al., 2025).

Descriptive bibliometric analysis (PH1)

Indicators of annual output, the geographical distribution of author affiliations and international collaboration were calculated. Keywords were standardised using a 60-entry English–Spanish table that harmonises synonyms and orthographic variants (e.g. 'digital competence' and 'competencia digital', or 'teacher education' and 'formación del profesorado'). International collaboration was defined as the presence of authors with affiliations in at least two different countries within the same article.

Semantic network analysis (PH2)

The co-occurrence of terms within the keywords of the same article indicates an explicit conceptual association. Accumulating co-occurrences across the corpus enables us to construct a network where the terms are the nodes and the co-occurrences are the weighted edges. Two filtering thresholds were applied to eliminate lexical noise whilst preserving stable conceptual associations: a minimum term frequency of ≥5 articles and a minimum edge weight of ≥2 co-occurrences.

Three centrality metrics were then calculated for this network: degree centrality (the number of terms directly connected to a given term), betweenness centrality (the frequency with which a given term appears on the shortest path between any two nodes in the network), and eigenvector centrality (influence weighted by the influence of neighbouring nodes). To identify conceptual communities — groups of terms that co-occur more frequently with one another than with the rest of the network — the Louvain algorithm (Blondel et al., 2008) was applied. This algorithm optimises the Q-modularity of the partition, which is an index that compares the internal connection density of each community with that expected in a random network of the same size (range: 0–1; Q values >0.2 are considered indicative of a non-random community structure). A random seed (seed=42) was set, and 100 initialisations were carried out to ensure reproducibility of the partition. Additionally, networks were constructed for sub-periods (2019–2021, 2022–2023 and 2024–2025) using a reduced threshold (freq≥3), examining the temporal dynamics of the field.

Methodological and discursive classification (PH3)

Two rule-based lexical classifiers were designed to analyse the abstract text of each article. In both cases, each category is associated with a list of regular expressions that are characteristic of that category. The article is assigned to the category whose expressions yield the most matches. The methodological classifier distinguishes between the following six categories: quantitative (scales, questionnaires, ANOVA and SEM); qualitative (interviews, focus groups and case studies); mixed; systematic reviews; design and development; and theoretical. The discursive classifier distinguishes between the following four orientations: instrumental (effectiveness, performance and optimisation); interpretative (meanings and experiences); critical (inequality, power and justice); and techno-systemic (technical architecture, algorithms and analytics). Articles without sufficient lexical cues are classified as 'Unclassifiable'.

Exploratory epistemological analysis (PH4)

Lexical classifiers were applied to the combined text of abstracts and keywords to identify four dimensions: functional position (primary production, recontextualization of external frameworks and contested recontextualization); classification strength (+C: own educational theoretical frameworks; –C: frameworks imported from other disciplines or from supranational policy); framing strength (+F: alignment with the empirical-quantitative canon; –F: open formats) and type of vertical discourse (applied region, generic supranational policy discourse, disciplinary singularity, critical tradition). These classifiers are based on the operationalisation of pedagogical devices proposed by Bernstein (1990).

In parallel, nine independent thematic clusters were constructed using K-Means clustering (k=9; n_init=50; seed=42), based on the TF-IDF representation of the keywords in each article (min_df=3; max_df=0.85; n-gram=1–2; sublinear TF; L2 normalisation). This procedure is methodologically independent of the PH2 network analysis, thereby avoiding the circularity that would arise if the same instrument were used to construct the categories and classify the articles. The quality of the clustering was assessed using the Silhouette Index (Cosine Metric), and agreement with Louvain communities was evaluated using the Adjusted Rand Index (ARI) and Normalised Mutual Information (NMI).

To validate the automatic classifications based on the abstracts, the full texts of the three most representative articles from each cluster were used (n=27; determined by maximum cosine similarity with the cluster centroid). For each article, the Bernstein dimensions were coded with AI assistance using textual quotations from the article itself. The percentages of agreement between the automatic classification and the AI-assisted reading are reported by cluster, enabling us to identify which claims are supported by the available data and which require further work. This phase is exploratory in nature and its results should be interpreted as hypotheses emerging from the data.

3. Results

3.1. Bibliometric structure (PH1)

The corpus's output remains stable throughout the period analysed. The year with the highest output is 2020 (n=89; 16.5% of the corpus), coinciding with the onset of the COVID-19 pandemic and the surge in publications on emergency digitalisation in education. From 2021 onwards, output has fluctuated between 78 and 92 articles per year, with no sustained trend of growth or decline.

Table 2. Distribution of articles by year

2019	2020	2021	2022	2023	2024	2025
17	89	78	92	91	87	84
3,2 %	16,5 %	14,5 %	17,1 %	16,9 %	16,2 %	15,6 %

The geographical distribution reveals a significant concentration in Spain. Of the 1,558 author entries recorded, 1,225 correspond to authors with a Spanish affiliation (78.6%). The next five countries are Mexico (60 authors; 3.9%), Chile (47 authors; 3.0%), Ecuador (40 authors; 2.6%), Colombia (32 authors; 2.1%) and Portugal (30 authors; 1.9%). All other countries in the Ibero-American region have a marginal presence of less than 1%.

International collaboration is limited: 54 articles (9.9% of the corpus) have authors from more than one country. The structure of collaboration is radial, with Spain as the central node in all frequent pairs: Spain-Mexico (12 articles), Chile-Spain (n=9), Spain-Portugal (n=8) and Ecuador-Spain (n=4). The average number of authors per article is 2.86 for the entire corpus. Keyword analysis reveals that 'higher education' is by far the most frequent term in the corpus (n=117, 21.4% of the total), followed by 'digital competence' (n=47), 'ICT' (n=47), 'educational technology' (n=43), and 'artificial intelligence' (n=34). Table 3 lists the fifteen most frequent terms and their temporal distribution at either end of the period.

Table 3. Most frequent keywords in the corpus (top 15) with a comparison of 2019–2021 vs. 2023-2025

Normalised term	Total N	% of corpus	2019-21	2023-25
Educación superior	117	21,4 %	43	73
Competencia digital	47	8,6 %	18	29
TIC	47	8,6 %	22	20
Tecnología Educativa	43	7,9 %	18	24
Inteligencia artificial	34	6,2 %	3	31
Enseñanza superior	28	5,1 %	13	13
Género	20	3,7 %	9	11
Redes sociales	18	3,3 %	7	9
Formación del profesorado	19	3,5 %	8	10
Educación a distancia	17	3,1 %	8	8
Estudiantes universitarios	17	3,1 %	7	10
Innovación educativa	16	2,9 %	7	9
Educación secundaria	15	2,7 %	7	7
Motivación	14	2,6 %	6	7
Aprendizaje en línea	13	2,4 %	5	7

The term 'artificial intelligence' warrants specific attention due to its temporal dynamics. Virtually absent until 2022 (n=3 in the 2019–2021 subperiod), it experienced rapid growth in 2024 (n=11 articles published that year; 12.6%), which intensified in 2025 (n=21; 25% of all articles published that year). This growth is unprecedented for any other term in the corpus during the analysed period and does not reflect a gradual trend, but rather two distinct jumps: one in 2024 and another in 2025.

3.2. Semantic co-occurrence network of keywords (PH2)

The global network, constructed using established thresholds, comprises 66 nodes and 140 edges. Only 6.5% of the 2,145 possible connections between these 66 terms are actually present (density=0.065). The average clustering coefficient (0.074) is low: terms that share a neighbour are not usually directly connected to one another. These two indicators are consistent with a field in which vocabulary is widely shared across subfields and conceptual boundaries are porous.

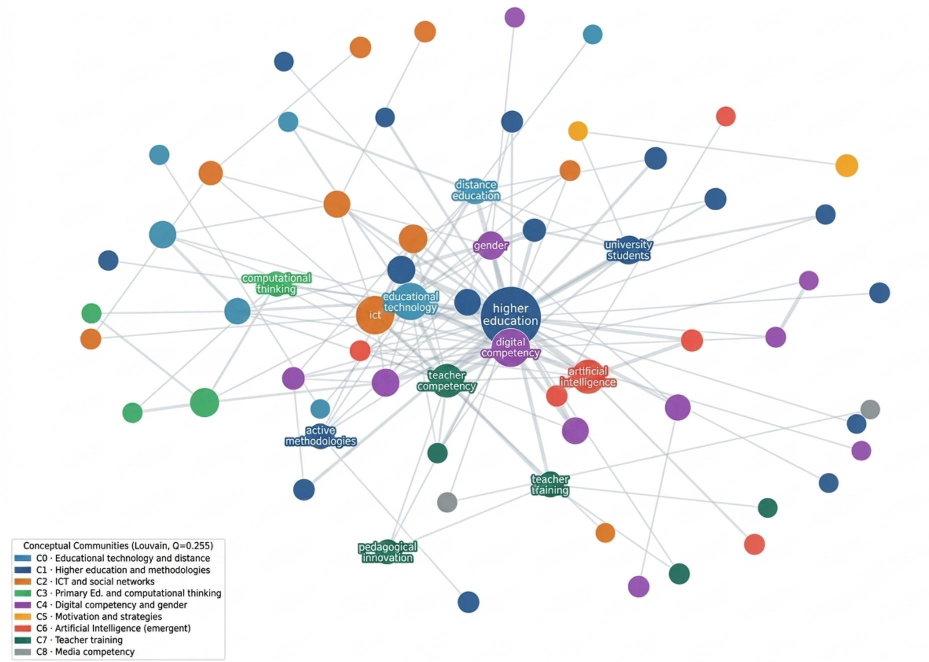

Figure 1. Global co-occurrence network of keywords (n=546 articles; 66 nodes; 140 edges)

The Louvain algorithm identified nine conceptual communities with a modularity of Q=0.255, which is above the reference threshold (Q>0.2) and indicates a non-random community structure. Table 4 lists the communities and their central terms.

Table 4. Conceptual communities identified by the Louvain algorithm

C	Label	Terms with the highest betweenness centrality	Size (n terms)
C0	Educational technology and distance learning	Educational technology, distance learning, augmented reality	8
C1	Higher education and methodologies	Higher education, active methodologies, online learning, university students	18
C2	ICT and social media	ICT, social media, university, teaching skills	9
C3	Primary education and computing	Computational thinking, primary education, STEM/STEAM	4
C4	Digital competence and gender	Digital competence, gender, academic performance, teaching staff	11
C5	Motivation and strategies	Learning strategies, motivation	2
C6	Artificial intelligence	Artificial intelligence, ethics, critical thinking, ChatGPT	6
C7	Teacher education	Teacher education pedagogical innovation	6
C8	Media competence	YouTube, media competence	2

The centrality analysis reveals a radial structure. The term 'higher education' ranks first in both degree centrality (0.600) and betweenness centrality (0.427): it is directly connected to 6 out of every 10 terms in the network and appears on the shortest path between almost half of all possible pairs of terms. This pattern indicates that 'higher education' is not only the most frequent topic in the corpus, but also the concept that structurally articulates the network: the bridge through which most conceptual associations are connected. The terms with the second and third highest betweenness are 'ICT' (0.176) and 'educational technology' (0.158), which are also context or domain labels rather than theoretical concepts.

Table 5 lists the ten terms with the highest betweenness centrality. The position of 'artificial intelligence' in fifth place (betweenness = 0.104), above more established terms such as 'teacher education' (0.079), suggests that it acts as a bridge node, connecting conceptual communities that would otherwise be unrelated.

Tabla 5. Diez términos con mayor centralidad de intermediación en la red global.

Term	Degree centrality	Betweenness centrality	Eigenvector	Frequency (no. of articles)
Higher education	0,6	0,43	—	139
ICT	0,23	0,18	—	47
Educational technology	0,23	0,16	—	43
Digital competence	0,28	0,14	—	47
Artificial intelligence	0,14	0,1	—	34
Active methodologies	0,08	0,1	—	12
Gender	0,12	0,09	—	21
Distance learning	0,14	0,08	—	17
Teacher education	0,2	0,08	—	34
University students	0,09	0,07	—	22

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Analysis by sub-period shows that community C6 (Artificial Intelligence) exhibits the most pronounced dynamics: with a connection density of virtually zero in the 2019–2021 sub-period, it takes on a recognisable community structure in 2022–2023 and consolidates as a community with high betweenness in 2024–2025. During this period, its central terms (artificial intelligence, ChatGPT, ethics and critical thinking) experience the highest year-on-year growth rates in the corpus. No other community exhibits comparable temporal dynamics over the analysed period.

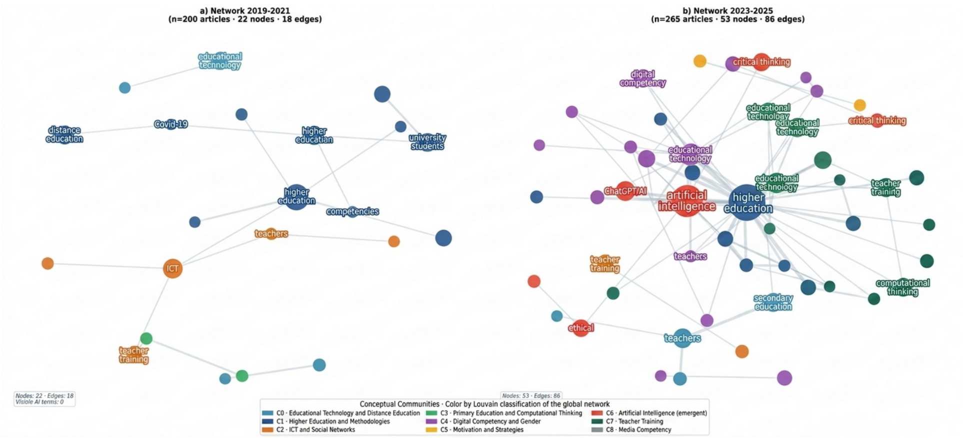

Figure 2. Comparison of semantic co-occurrence networks of keywords by sub-period: 2019-2021 (panel a) and 2023-2025 (panel b)

3.3. Methodological and discursive orientation (PH3)

The corpus is dominated by quantitative studies: 60.8% of the articles (n=332) employ empirical-quantitative designs using validated instruments and inferential statistics. Other methodological approaches are significantly less prevalent, with qualitative studies accounting for 11.5% (n=63), design and development studies accounting for 6.8% (n=37), systematic reviews 4.8% (n=26), mixed 2.0% (n=11), and theoretical 0.5% (n=3). 13% of the articles could not be classified due to insufficient methodological information in the abstract.

In terms of timing, 2020 accounted for the highest proportion of qualitative and design studies. From 2022 onwards, there has been a sustained upward trend in systematic reviews (from 1.1% in 2022 to 9.2% in 2024).

The instrumental-discursive orientation clearly dominates the corpus (61.7%; n=337): the central argument of these articles focuses on the effectiveness, performance, or optimisation of tools and strategies without reflecting substantively on the underlying conditions or values. The other approaches were less prevalent: interpretative 11.2% (n=61); critical 5.3% (n=29); and techno-systemic 5.5% (n=30). 16.3% of the articles could not be classified.

Techno-systemic discourse, which focuses on technical architecture, algorithms and learning analytics, deserves specific attention due to its trajectory: virtually absent in 2022 (0.0%), it reached 10.7% in 2025. This growth coincides exactly with that of the conceptual community of artificial intelligence within the semantic network, and it is the only discursive shift with a temporal dynamic comparable to the emergence of AI as a research topic.

Table 6. Methodological and discursive distribution of the corpus

Category	n	%	2020 (% year)	2025 (% year)
Methodological Orientation				
Quantitative	332	0,61	0,54	0,64
Qualitative	63	0,12	0,16	0,1
Design and development	37	0,07	0,08	0,07
Unclassifiable	74	0,14	0,14	0,12
Systematic review	26	0,05	0,01	0,1
Mixed	11	0,02	0,05	0,01
Theoretical	3	0,01	0	0,01
Discursive Orientation				
Instrumental	337	0,62	0,63	0,64
Unclassifiable	89	0,16	0,16	0,13
Interpretative	61	0,11	0,11	0,1
Techno-systemic	30	0,06	0,05	0,11
Critical	29	0,05	0,06	0,02

3.4. Exploratory epistemological analysis: thematic clusters and field orientation (PH4)

The silhouette index for K-Means clustering (s=0.055) is low and stable for k between 4 and 11. This indicates that articles share vocabulary across subfields, and that no method can clearly distinguish between them. Agreement with the Louvain communities is generally low (ARI=0.077; NMI=0.204), but it does follow an interpretable pattern. Clusters with specific terminology converge across methods (e.g. Augmented/Virtual Reality: 88%; Online Learning: 71%), while those with generic vocabulary diverge (e.g. ICT and Information: 9%; Teacher Training: 13%). This indicates clearer conceptual boundaries where subfields deal with specific technological objects.

Bernsteinian classifiers applied to the overall corpus reveal a consistent profile across the dimensions best captured by the abstracts: a predominance of strong framing (+F: 65.8 per cent of articles), which characterises conformity to the empirical-quantitative article canon.

There is also a predominance of vertical discourse in the applied region (69.6 per cent), which characterises the importation of frameworks from adjacent disciplines without any pedagogical reformulation. Finally, there is the previously described dominance of instrumental orientation. 84% of the articles are classified as 'Undeterminable' in the functional position dimension, indicating that academic abstracts rarely explicitly state the article's theoretical position within the field.

Table 7. Results of the full-text validation of the K-means clusters

Cluster	Label	No. of articles	Position agreement	Frame agreement	Main finding of the manual validation
KM0	Digital competence	52	46084	46083	It is based entirely on European ORF frameworks (DigComp, DigCompEdu). Discrepancy: the editorial is classified as an empirical article.
KM1	ICT and information	56	46082	46083	The most heterogeneous cluster. Classifier confusion: empirical rigour ≠ theoretical output; adoption of ORF terminology ≠ alignment with it
KM2	Teacher education	52	46082	46082	Classifier fails on qualitative articles and systematic reviews (few markers in the abstract)
KM3	Augmented/ virtual reality	17	46084	46084	Full confirmation. Systematic discrepancy in vertical discourse: TAM and psycholinguistics ≠ supranational ORF
KM4	Artificial intelligence	38	46084	46084	Perfect agreement. Only cluster with disputed recontextualization (1 article)
KM5	Higher education in general	155	46084	46084	Perfect agreement. Modal profile of the field: +F, applied region, uncritical recontextualization
KM6	Primary education and STEM	72	46084	46082	Coexistence of genuine +F articles and descriptive –F essays using the same STEM lexicon
KM7	Online learning	40	46084	2,5/3	High concordance. The mobilised ORF varies between articles (OECD, UTAUT, UNESCO/ISTE)
KM8	Higher education and social media	64	46083	46084	The primary production predicted by the classifier is an artefact of imported theoretical density.

Full-text validation revealed two patterns of systematic error that have implications for the overall interpretation. The first pattern is confusion between methodological rigour and original theoretical output. Articles with a large sample size and complex statistics are automatically classified as 'primary production' when, in fact, they are applied studies without any new theoretical contribution. Secondly, there is a confusion between the formal adoption of supranational language and ideological alignment with it. The classifier fails to detect when an article uses the ORF's vocabulary

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to challenge it because the challenge is expressed through the content and choice of terminology rather than lexical signals of confrontation.

4. Discussion and conclusions

The results of this study allow us to describe the field of Educational Technology research in Ibero-America as 'applied', as defined by Bernstein (2000): an area that combines knowledge from various disciplines without forming a single discipline with its own organisational principles. This situation is not problematic in itself; what is important is how this integration takes place. In the analysed corpus, recontextualization predominantly appears uncritical and dependent, in line with previous work (Hew et al., 2019; Zawacki-Richter et al., 2019). This suggests the adoption of external frameworks, whether psychological, technological, or from supranational bodies, without any substantive pedagogical transformation. The strong presence of frameworks such as DIGCOMP or technology adoption models does not result in strictly pedagogical theoretical development, but rather in their instrumental application. This predominance of dependent recontextualization is linked to a specific structure of the pedagogical framework: the combination of weak classification (–C) and strong framing (+F).

The low density and porosity of the semantic network demonstrate, on the one hand, that the field lacks robust conceptual boundaries, in line with Maton's (2014) description of regions with low epistemological density. Within this framework, the near-universal adoption of the IMRaD format and the validation paper (Bazerman, 1988; Latour & Woolgar, 1986) indicates a significant level of control over the structure of scientific discourse (60.8% quantitative, 61.7% cent instrumental and 0.5% theoretical). This asymmetry — weak conceptual structuring and strong formal regulation — not only organises production, but also determines what kind of knowledge can be recognised as valid. Inclusion in the first quartile (Q1) of the studied journals acts as an epistemological filter that favours mainstream formats and frameworks. This allows us to hypothesise that the observed uncritical recontextualization is not a choice made by individual authors, but rather an effect of the circuit's position within the global system (Beigel & Sabea, 2014). The marginalisation of critical writing in the corpus (5.3%) suggests that dominant evaluation rules, such as the validation paper and its psychometric requirements, are reluctant to accommodate critical writing formats, such as the essay, investigative narrative and autoethnography (Beigel, 2014; Selwyn, 2024).

From a temporal perspective, the results show that, between 2019–2021 and 2024–2025, the field shifted from the lexicon of distance learning, MOOCs and pandemic communication to a focus on GenAI, ChatGPT and prompts, whilst there was an increase in psycho-educational terms such as 'performance', 'motivation', 'perception' and 'emotional state'. Within this framework, the topology of the network itself is being reorganised around an emerging core of university-digital-AI-education, which is interwoven with other communities in the graph. The emergence of GenAI coincides with sustained growth in techno-systemic discourse (rising from 0% in 2022 to 10.7% in 2025) and systematic reviews (rising from 1.1% in 2022 to 9.2% in 2024). However, there has been no equivalent growth in critical discourse or theoretical output. If this trend continues, it suggests that the field is adopting AI in an instrumental manner rather than problematising it. Its rapid rise to prominence indicates its capacity to convey the generic discourse of the ORF: a rhetoric of innovation and efficiency that directs research agendas towards what is technically possible rather than what is pedagogically necessary (Selwyn, 2024). This is particularly relevant because, unlike previous technologies, GenAI operates directly on discourse, generating texts, assessments, plans, and feedback, and thus intervening at the very heart of the pedagogical apparatus (RIED, 2025; Williamson et al., 2023). This shift has an additional geopolitical dimension: GenAI is a technology produced at the centre of the global system (OpenAI, Anthropic, Google) and predominantly trained in English. Recontextualising it uncritically within the Ibero-American sphere would reinforce academic dependence at a time when the technology itself could destabilise the rules governing validation papers and open up a space for new forms of knowledge production (Beigel & Persia, 2024).

The structural stability of the 'higher education' context label as a bridging node within the field suggests that all discourse passes through these signifiers, regardless of technology or historical period. This suggests that while technology changes, the nominal pedagogical subject and the institutional context of the field remain fixed — a manifestation of the strength of regulatory framing. Pedagogical discourse is anchored in a fixed matrix, with technological and methodological variations superimposed upon it (Maldonado-Diaz, 2022).

One methodological contribution that deserves to be highlighted is that the available indicators — low lexical separability between subfields, dominance of applied regional discourse and a high rate of 'Undeterminable' in functional position — are consistent with the hypothesis of a field with weak conceptual autonomy. This field's theoretical agenda is defined more by available technologies and supranational policy frameworks, such as DigComp and OECD, than by questions arising from within the field itself. However, this hypothesis would require verification through full-text analysis and coding by independent pairs.

Finally, it is worth noting that the incorporation of computational techniques (TF-IDF, Louvain, K-Means and NMF) in this study is justified by their ability to process large amounts of data and detect structures that manual methods cannot. However, this methodological choice recognises its limitations in light of the finding that, when AI appears as a research subject in the analysed journals, it is predominantly framed in instrumental and techno-systemic terms (26.0% in the AI cluster compared with 5.5% overall), lacking critical reflection. This automated analysis may demonstrate that computational tools can be used to critically interrogate the uncritical recontextualization of imported technologies without reproducing the same instrumental logic.

5. Contributions of the authors

AGB: conceptualisation, analysis, drafting of the original manuscript, critical review and final editing of the text. UR: Methodology, analysis, critical review. AGV: State of the art, analysis, drafting

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ARTICLE / ARTÍCULO

Personalized Learning Supported by Digital Technologies: Trends, challenges and perspectives

Aprendizaje personalizado facilitado por tecnologías digitales. Tendencias, retos y perspectivas

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Resumen: Since the establishment of compulsory education, the personalisation of learning has been a recurring concern in educational research and practice, in which educational technology has always played a part. This paper analyses the state of the art on personalized learning supported by digital technologies, identifying trends, challenges and perspectives from Educational Technology as a discipline. It adopts the form of a theoretical essay based on a narrative review of literature, focused on review articles and conceptual frameworks published in specialised journals. The analysis identifies two main strands of personalisation, articulated around the continuum proposed by Cuban (2018): one centred on technological adaptation through algorithms, learning analytics and intelligent tutoring systems, and another oriented towards curricular flexibility and student agency through personal learning environments, flexible pathways and co-design processes. Generative artificial intelligence acts as an accelerator for both strands yet intensifies the risk that the appearance of personalisation may replace genuine learning. Conceptual, institutional, psychological, technological and pedagogical barriers to implementation are identified. The paper concludes that personalisation is not essentially a technological problem but a pedagogical one, and that it must attend both to the evolution of technologies and to human supervision in the construction of learning.

Keywords: Personalized Learning, Artificial Intelligence, Self Regulated Learning, Learner Autonomy, Educational Technology, Adaptive Instruction.

Abstract: Desde la generalización de la educación obligatoria, la personalización del aprendizaje ha constituido una preocupación recurrente en la investigación y en la práctica pedagógica, en la que la tecnología educativa ha estado siempre presente. Este trabajo analiza el estado de la cuestión sobre la personalización del aprendizaje facilitada por tecnologías digitales, identificando tendencias, retos y perspectivas desde la Tecnología Educativa. Para ello, adopta la forma de ensayo teórico basado en una revisión narrativa de literatura, centrada en trabajos de revisión y marcos conceptuales publicados en revistas especializadas. El análisis identifica dos grandes vertientes de la personalización, articuladas en torno al continuo propuesto por Cuban (2018): una centrada en la adaptación tecnológica, mediante algoritmos, analíticas de aprendizaje y sistemas de tutoría inteligente, y otra orientada a la flexibilización curricular y a la agencia del estudiante, mediante entornos personales, itinerarios flexibles y procesos de codiseño. La inteligencia artificial generativa actúa como acelerador de ambas vertientes, pero intensifica el riesgo de que la apariencia de personalización sustituya al aprendizaje real. Se identifican barreras conceptuales, institucionales, psicológicas, tecnológicas y pedagógicas que dificultan su implementación. Se concluye que la personalización no es esencialmente un problema tecnológico, sino pedagógico, y que debe atender tanto a la evolución de las tecnologías como a la supervisión humana en los procesos de construcción del aprendizaje.

Palabras-clave: Aprendizaje personalizado, Inteligencia artificial, Aprendizaje autorregulado, Autonomía del aprendiz, itinerarios flexibles de aprendizaje, Tecnología educativa, Instrucción adaptativa.

1. Introduction

Personalized learning has been one of the key areas of research and pedagogical practice associated with the evolution of educational technology since the early 20th century. In a context of universal, public, and compulsory education, the inability to address diverse needs, interests, abilities, family cultures, and cognitive styles makes personalization one of the key areas of pedagogical research.

Personalized learning is essentially an extension of an earlier solution to a persistent problem: there are far more students than teachers. Therefore, instruction must be one-to-many, but students arrive with different levels of preparation and require different amounts of practice to master schoolwork, making it unlikely that a single curriculum will be effective for everyone. Chan and Gastelum (2016, p. 85) note that

> «the personalization of learning is an old movement pedagogically speaking; technologically, it is relatively new, and it is 'yet to come' in terms of curriculum organisation and, above all, the didactic or instructional design of online courses»

The concept of personalized learning (understood as addressing students' individual needs) finds in the application of digital technologies, the possibilities of artificial intelligence, and other emerging technologies a means to develop tools, approaches, and practices that seek to adapt the teaching-learning process to individual characteristics, itineraries, and motivations (Salinas and Lizana, 2025).

There have always been attempts to rely on technology to contribute to this personalization. The first teaching machines were purely mechanical. Sidney Pressey was the first to use "intelligent" machines for educational purposes (Pressey, 1926); later, Skinner (1954) developed the machine that would become the precursor to programmed learning (linear programming), and Crowder (1962) introduced Branching Programming or Intrinsic Programming. In fact, the first computers applied to education in the 1960s sought to implement strategies based on this type of programming, allowing for greater sophistication in tutoring possibilities and, consequently, greater adaptation to individual learning.

Personalized tutoring was the focus of psychological, pedagogical, and didactic theory and practice during this period, especially regarding technology-enhanced learning. Bloom (1984), for example, argued that the most effective way to teach was through individualised tutoring.

As educational technology matured in the second half of the last century, personalized learning took the form of intelligent tutoring systems. The development of microprocessors shifted the focus toward providing teachers with tools to produce computer-assisted instructional materials. The first authoring languages appeared, such as the pioneering Coursewriter, as well as Autotutor, Pilot, and Natal, followed in the 1980s and 1990s by Hypertalk, Toolbook, and Authorware.

At the same time, pedagogical foundations began shifting toward constructivism and the student-centred educational paradigm, which provided a theoretical justification for why teaching methods and content should be personalized.

In this century, big data, learning analytics, and other advances have led to personalized learning becoming a major focus of research (Shemshack and Spector, 2020). The transformative potential of technology appears to hold significant promise for a more equitable and personalized education. However, all these advances carry risks that accompany the promise of personalized learning. One such risk is individualisation, which can isolate students in algorithmic learning pathways, undermining the social aspect of education. But there are others, such as the paradox of empty dialogue (Mas, 2023) or the challenges raised by Barrera et al. (2025).

The researchers believe that a personalized learning experience facilitated by digital technologies can contribute to better learning for all. Thus, this study analyses current trends, research, and practices related to this topic. To achieve the objective of this study, the following research question was posed: What elements comprise a pedagogical approach to personalized learning from a holistic perspective?

This question can be broken down into several sub-questions that allow for a more specific focus on the study:

1) Is it possible to arrive at a definition of personalized learning from the perspective of educational technology?
2) What are the dimensions of personalized learning enabled by technology that should be considered?
3) What trends in research and practice are observed in the educational landscape?
4) What are the main challenges perceived in relation to personalized learning facilitated by digital technologies?

To explore possible answers, this paper takes the form of a theoretical essay that, based on a narrative review of relevant literature, analyses the state of the art regarding personalized learning facilitated by digital technologies. Articles from databases and journals specializing in educational technology were reviewed and selected based on their relevance, recency, and quality, with a preference for review articles and conceptual frameworks. The purpose is not to provide an exhaustive review, but rather to offer an integrative overview from the perspective of Educational Technology as a discipline.

1.1. What do we mean by personalized learning?

The idea of personalized learning stems from the principle that human beings learn through experience and by constructing knowledge. The term seems deceptively simple and common, but its use in an educational context is complex and involves many nuances. In other words, it can mean different things.

According to Conole (2010), personalization and personalized learning can be approached from three perspectives, and their definition will differ accordingly: in political discourse, in relation to technological advances, and in pedagogical discourse.

Numerous definitions of personalized learning have been published by government agencies, organisations dedicated to education policy, foundations and educational initiatives, influential figures, and researchers. Both Walkington and Bernacki (2020) and Bernacki et al. (2021) compile and classify several of these definitions, highlighting the variation in the characteristics included in them. These variations encompass both student characteristics to be accommodated, design elements, and the intended outcomes.

According to Coll (2015), personalization involves designing and developing learning experiences that cater to the diversity of learners, considering their characteristics, needs, and interests.

In the field of digital technologies, according to Spector (2018), for a digital learning environment to be classified as a personalized learning environment, it must adapt to everyone's knowledge, experience, and interests, and it must be effective and efficient in supporting and fostering desired learning outcomes.

Cuban (2018) proposes a spectrum or continuum to organise this diversity of meanings, identifying three key zones: At one end of the continuum are teacher-centred lessons and programs within the traditional school setting; in the middle of the spectrum are hybrid programs and schools that offer combinations of whole-class, small-group, and independent work activities; and at the other end of the spectrum are student-centred classrooms, programs, and schools with multi-age groups that pose big questions integrating reading, math, science, and social studies, while regularly incorporating new technologies into lessons.

When understood as addressing students' individual needs, the personalization of learning finds in the application of digital technologies the development of approaches and tools that aim to adapt the teaching-learning process to individual characteristics, itineraries, and motivations.

However, as Varona-Klioukina and Engel (2024) point out, recent reviews of the relationship between personalized learning and digital technologies tend to lean more toward teacher-centred approaches, according to Cuban's (2018) terminology—which use digital technologies to adapt learning activities and content to students' individual performance (technology as a content delivery mechanism)—rather than learner-centred proposals, in which students are recognised and empowered to make decisions about their own learning process, based on their interests and preferences (technology as a creative tool).

Algorithms capable of responding to individual differences, the implementation of learning analytics, the use of educational recommendation systems, the integration of chatbots, and, more recently, the application of technologies based on generative artificial intelligence (GenAI) are some of the ways digital technologies are applied to the personalization of learning from various perspectives (Varona-Klioukina and Engel, 2024)

All of this could represent a significant step forward in the pursuit of a more equitable and personalized education, supported by the transformative potential that technology appears to possess. However, it carries the risk of individualisation, which could isolate students within algorithmic learning paths, thereby undermining the social aspect of education.

2. Dimensions of Personalization

Just as with the definition of personalization, the dimensions or components that determine such personalization are approached from different perspectives (Hargreaves, 2004; Järvelä, 2006; FitzGerald et al., 2018; Shemshack et al., 2021). Shemshack et al. (2021), for example, in their review of the components of personalized learning used in different approaches and models, consider learning styles, cognitive styles, self-reflection and self-regulation of learning, flexible itineraries, tools and systems, intelligent learning environments, intelligent tutoring systems, data mining and learning analytics, and wearable devices.

In analysing the similarities and differences among the components used in personalized learning approaches, these authors observed that, although cognitive components were initially the centre of attention, the focus has gradually expanded to include non-cognitive components (Esteban-Guitart and Moll, 2014).

For their part, when addressing how to apply personalization in technology-enhanced learning and how this can be effective for students and other stakeholders, FitzGerald et al. (2018) adapt the framework proposed by Hargreaves (2004), which classifies different dimensions of personalization, but in this case focuses on aspects of technology-enhanced learning. These six dimensions are:

- What is personalized: Personalization focuses on technology-enriched learning. This involves tailoring the educational experience: including resources, assessments, curriculum content, and specific learning plans; to the individual student (Walkington & Bernacki, 2020)
- The type of learning to which personalization is applied: This model applies to learning processes where technology acts as a mediator or enabler, ranging from literacy in elementary school to higher education and lifelong learning (Barrera-Castro et al., 2025)
- Which personal characteristics of the student can be considered: The design must consider variables such as the student's profile, learning styles, cognitive levels, prior knowledge, interests, personal goals, and specific inclusion needs (Barrera-Castro et al., 2025; Bernacki et al., 2021)
- Who or what carries out personalization: It can be carried out by technological systems (AI algorithms, intelligent tutoring systems), by the teacher (who acts as a guide or facilitator), or by the student themselves through the exercise of their agency, voice, and choice (Walkington & Bernacki, 2020)
- How personalization is carried out: FitzGerald et al. (2018) propose a framework that serves both to analyse existing practices and to create new, effective implementations of TE: Use of disruptive technologies and AI (Barrera-Castro et al., 2025; Reyes-Parra et al., 2024); system adaptability vs. learner adaptability (Kucirkova et al., 2021; Sachete et al., 2024); instructional design adjustments; biometric and

contextual monitoring (Reyes-Parra et al., 2024); creation of flexible learning pathways (Salinas et al., 2022).

- The impact and beneficiaries of personalization: Personalization seeks to improve the quality of education, promote equity and inclusion, and facilitate effective time management in educational activities (Barrera-Castro et al., 2025; Reyes-Parra et al., 2024). The direct beneficiaries are students, although it also has a positive impact on teaching practices and, in many cases, on institutions by reducing learning gaps.

For their part, Lee et al. (2018) propose five essential components that personalized learning should include: 1) a personalized learning plan that takes individual differences into account, 2) tracking student progress based on competencies rather than time, 3) criteria-based assessment rather than norm-based assessment for ongoing formative and summative evaluation, 4) project- or problem-based learning, and 5) multi-year mentoring of students by a teacher or tutor.

3. Trends

The potential of technology to adapt the learning process to individual differences represents a megatrend in research, theoretical development, and practice. This megatrend, when situated within Cuban's (2018) continuum, in turn presents different aspects. On the one hand, learning analytics (algorithms aimed at adapting the curriculum, the use of robots, virtual tutors, and adaptive platforms) that do not challenge teacher-centred approaches. On the other hand, greater curricular flexibility, the cultivation of competencies related to autonomy and agency, and the construction of one's own personal learning environment which, from learner-centred approaches, lead to greater personalization of experiences in pedagogical practice. Figure 1 summarises the main trends identified in these areas.

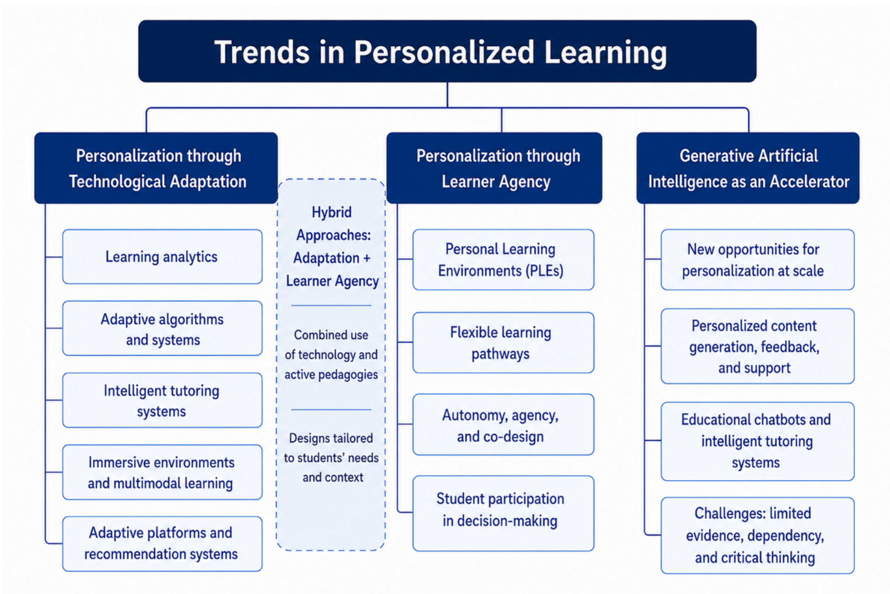

Figure 1.Trends in the Personalization of Learning. Note: Image generated by ChatGPT 5.5 based on a descriptive prompt

3.1. Personalization Through Technological Adaptation

In the first aspect, Varona-Klioukina and Engel (2024) highlight the design of various algorithms that can address individual differences, as well as the use of learning analytics, educational recommendation systems, the integration of chatbots, and, currently, the application of generative artificial intelligence. Intelligent and adaptive educational systems have sought to support students and teachers by providing meaningful, relevant, and appropriate educational content. However, in practice, adaptability has focused primarily on the personalized presentation of content and adaptive navigation through it (Walkington and Bernacki, 2020), leaving other dimensions of learning in the background.

The potential of learning analytics has been a widely explored trend in recent years (Chatti and Muslim, 2019; Zhang et al., 2018). This trend is currently gaining momentum due to models that enable predictive interventions (such as identifying the risk of dropout or detecting changes in learning dynamics or misconceptions before they become entrenched). In any case, this trend still lacks evidence beyond experimental projects and pilot studies.

Another area within this trend is immersive environments. Extended reality (which includes virtual reality, augmented reality, personalized labs, simulators, etc.) offers the possibility of customising not only the content but also the physical context of learning.

In the field of multimodal learning, technological advances have already led to interfaces that read voice, facial expressions, writing speed, and other biometric data from which affective and cognitive states can be inferred.

Traditional, rule-based intelligent tutoring systems are beginning to be replaced by systems capable of sustaining a genuine Socratic dialogue. Research in this area will need to examine these types of dialogic interventions, how and to what extent they impact learning, and how to calibrate the level of support without creating dependency (Bernacki et al., 2021).

3.2. Personalization Based on Learner Agency

In the second aspect, these authors focus on the application of digital technologies through student-centred approaches, in which students are recognised and empowered to make decisions about their own learning process, based on their interests and preferences. Here, students participate in identifying their needs and preferences. But they are not only involved in identification; they are also engaged in determining how to respond based on their personal interests and choices through a process of co-designing learning experiences. The potential of digital technologies to facilitate such flexibility and contribute to the adaptation of teaching-learning processes has led to extensive research and the emergence of various models.

Within the framework of a broader personalization strategy, the term "personal learning environments" (PLE) has gained popularity over the past decade and highlights the social dimensions of learning (Conole, 2010). The application of digital technologies from the perspective of building personal learning environments (Adell and Castañeda, 2010) is geared toward individuals who are aware of their needs and limitations, who exercise a certain degree of autonomy in their learning, and who, in this sense, help reverse the trend of students adapting to a system that is increasingly tailored to the student.

According to Cuban (2018), flexible learning pathways provide students with sufficient flexibility to exercise autonomy in their own learning process through participation in decision-making (Bartolomé, 2020; Salinas and De Benito, 2020). In this sense, personalization would consist of developing personal competencies related to autonomy, agency, and the construction and cultivation of one's own personal learning environment.

Between these two aspects lies a whole range of experiences that make use of digital technology for adaptation (learning analytics, algorithms designed to adapt the curriculum and practices to these individual differences, the use of robots, artificial intelligence, etc.), as well as student engagement through innovative teaching methodologies or by adapting designs to users' needs and characteristics (Salinas and Lizana, 2025).

Undoubtedly, technology plays a key role in creating personalized learning environments, and technological advances make it possible to implement such environments on a large scale and at an affordable cost. However, very few studies have analysed how technology is used in the implementation of personalized learning and what the needs of teachers are in student-centred contexts when applying personalized learning (Lee et al., 2018).

In this context, a crucial aspect of personalization emerges that current educational technology barely addresses: the personalization of the entire learning environment, its components, tools, and functionalities. Students exhibit widely varying levels of digital competence, different preferences regarding the degree of guidance or autonomy they need and needs that change over time. This heterogeneity, coupled with the evolving nature of their demands as the learning process progresses, requires approaches with a higher level of adaptability (Chatti and Muslim, 2019).

3.3. Generative Artificial Intelligence as an Accelerator

Among the technologies highlighted in the first section, generative artificial intelligence (GenAI) deserves specific attention, both for the speed of its adoption and for the expectations it has generated in the field of education. As Serrano and Moreno-García (2024) point out, the emergence of large language models has reignited a recurring promise in the history of educational technology: that personalized tutoring at scale is, at last, possible. But they also warn of the risk of falling into what they call the "Law of the Polka": believing that something revolutionary has been discovered when, in reality, old ideas lacking sufficient empirical basis are simply being recycled.

The convergence of adaptive learning and IAGen, however, opens possibilities worth exploring. Current adaptive systems can combine the analysis of student performance with the generative capabilities of language models to produce content, feedback, and assessments tailored in real time (Guettala et al., 2024). Educational platforms already incorporate these capabilities, not only to adapt content and lessons but also, in some cases, to provide emotional support and foster interaction (Serrano and Moreno-García, 2024).

Educational chatbots are one of the most visible applications of this trend. Research indicates that they can improve learning outcomes, offer immediate assistance, and facilitate a certain degree of personalization. However, the effects on motivation, engagement, and, especially, critical thinking yield conflicting results (Labadze et al., 2023). Guan et al. (2024), in analysing chatbots' support for self-regulated learning, conclude that none of the systems studied offers comprehensive support across all phases of self-regulation, limiting themselves to specific tasks.

For their part, intelligent tutoring systems (ITS) perhaps hold the greatest promise for technological personalization. Based on machine learning algorithms to analyse large volumes of student data, these systems aim to simulate human tutoring and become proactive guides for learning. However, decision-making methods for designing personalized learning paths still have shortcomings, particularly in predicting content difficulty and in integrating motivational and emotional variables (Serrano and Moreno-García, 2024). The lack of empathy and emotional support remains one of the most frequently cited limitations, even in the most advanced systems.

All this calls for a fundamental reflection that connects both ends of the continuum. If the first end is advancing rapidly in the sophistication of algorithms and the second calls for the learner to play a greater role in decision-making, the tension between the two is not resolved with more technology, but with better pedagogy. Educational research, as has been repeatedly documented, lags technological development (Zawacki-Richter et al., 2019), and this gap has widened with the acceleration brought about by IAGen. There is a real risk that, as Mas (2023) warns with the paradox of empty dialogue, the appearance of personalization will replace genuine personalization: that a system will generate responses that appear tailored to the student without the student having been actively involved in the process.

These advances and tensions present us with a set of challenges that must be addressed.

4. Barriers to Personalization

The obstacles preventing the implementation of personalization are complex and of both a technical and pedagogical nature. In this context, the challenge facing the personalization agenda is how to identify and address these obstacles (Conole, 2010). Despite the widely documented benefits of personalized learning, significant challenges remain, especially in today's educational context, where emerging technologies—including artificial intelligence—are prevalent.

Barrera et al. (2025, p. 2) classify these challenges into five dimensions (Figure 2).

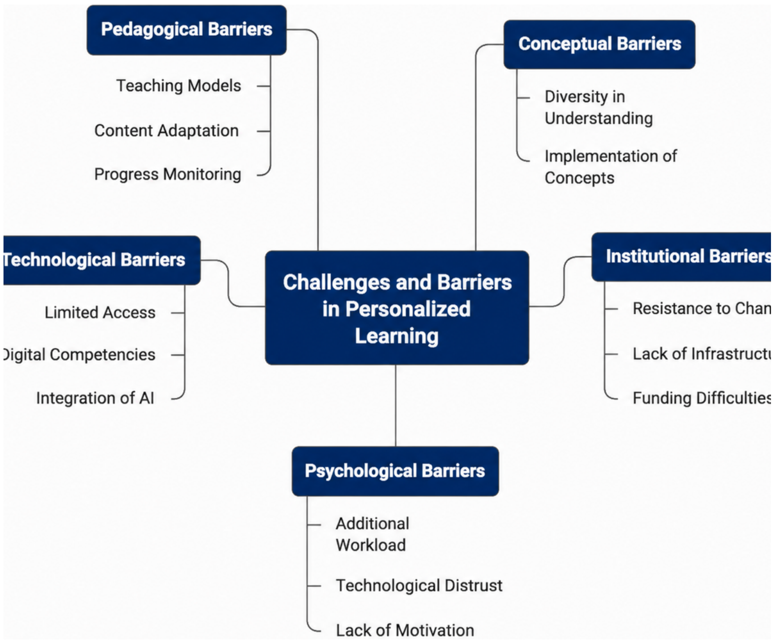

Figure 2. Challenges and barriers to personalized learning. Note: Image generated using the Napkin.ai app based on the content.

4.1. Conceptual barriers

There is a problem of diversity in the understanding and implementation of concepts related to the field of research (Spector, 2018; Varona-Klioukina and Engel, 2024; Walkington and Bernacki, 2020). Personalized learning and the personalization of learning are not terms on which there is consensus within the scientific community. There are different approaches to personalized learning that consider various components of learning. Personalized learning is defined differently in almost every context in which it is applied, and this diversity hinders research and evaluation of how it influences students' educational experience and academic outcomes (Walkington and Bernacki, 2020; Cuban, 2018).

4.2. Institutional barriers

Institutional structures, designed primarily for standardised teaching models, exhibit curricular, scheduling, and assessment rigidities that hinder the flexibility needed to accommodate individualised learning paths. Added to this are insufficient technological infrastructure, institutional support that rarely places personalization among its strategic priorities, and difficulties in securing sustained funding (Crespo, 2023). Time is a cross-cutting barrier: designing, implementing, and evaluating personalized learning experiences requires a level of dedication that is difficult to reconcile with typical teaching workloads (Chan and Gastelum, 2016).

4.3. Psychological barriers

The implementation of personalization faces resistance that is not technical but attitudinal. On the part of faculty, the fear of adopting new teaching methods and the difficulty in recognising the potential of available tools hinder pedagogical experimentation. On the part of students, research documents difficulties in maintaining sustained engagement with processes that require greater autonomy, as well as emotional factors (stress, anxiety) that must be considered in the design of personalized activities (Barrera-Castro et al., 2025).

4.4. Technological barriers

These include limited access to technology, gaps in digital skills, insufficient technical support, integration challenges, and ethical considerations (Hernández Cardenas et al., 2022; Walkington and Bernacki, 2020). Added to these barriers is a challenge specific to the present moment: the rapid pace of advances in generative AI makes it difficult for both educators and researchers to gain an in-depth understanding of a technology's possibilities before it has evolved and given way to new functionalities. Despite the exponential growth in studies on AI in education, recent reviews continue to identify the same gaps as a decade ago: insufficient attention to pedagogical and ethical aspects, limited participation by education professionals, and uneven methodological quality (Zawacki-Richter et al., 2019; Bond et al., 2024). Prendes and Serrano (2016) refer to this phenomenon as the "law of obsolescence": the results of research in educational technology are inevitably affected by the ephemeral nature of the technologies they study, so that findings that seem relevant may quickly become outdated. This disconnect is particularly pronounced in the case of IAGen, whose evolution seems to be measured in months, not years.

4.5. Pedagogical barriers

These refer to the models used for personalized instruction, a lack of the pedagogical knowledge needed to adapt content and learning activities, insufficient pedagogical support for teachers, fear of losing control over the curriculum, and the complexity of measuring and tracking students' individual progress (FitzGerald et al., 2018; Reyes-Parra et al., 2024; Salinas et al., 2022). In the current context, these barriers are exacerbated by the coexistence of learning environments designed with pedagogical intent and freely accessible generative AI tools that provide direct answers. This situation presents a specific challenge for personalized learning designs: even though teachers may provide guides, learning paths, or resources intended to foster reflection, support learning, and encourage student decision-making, students may turn to external tools that offer immediate solutions without requiring the same level of independent thought.

Recent evidence suggests that the use of generative AI without adequate pedagogical guidance may improve immediate performance on a task but hinder subsequent independent learning when students must work without technological support (Bastani et al., 2025). Furthermore, it has been noted that the support provided by these tools can foster forms of "metacognitive laziness", in which the final product improves without necessarily resulting in an equivalent gain in comprehension, transfer, or self-regulation of learning (Fan et al., 2024). This aspect introduces an additional pedagogical barrier: designing uses of generative AI that maintain students' cognitive engagement and avoid replacing the processes of comprehension, elaboration, and self-regulation that are integral to personalized learning.

5. Emerging Perspectives and Challenges

The discussion so far allows us to identify a set of perspectives and challenges that characterise the current state of personalized learning facilitated by digital technologies and that are likely to shape its evolution in the coming years.

The current landscape revolves around a tension that runs the entire length of the continuum described by Cuban (2018). On the one hand, there is the tension between technology-driven personalization; in which algorithms, analytics, and intelligent tutoring systems make decisions about what to present, in what order, and at what difficulty level. On the other hand, there is the student-driven personalization, in which students participate in identifying their needs and co-designing their learning path, with the support of the teacher (Salinas and De Benito, 2020; Varona-Klioukina and Engel, 2024).

This tension is not new, but each pole faces barriers of a different nature. Adaptive approaches tend to reduce personalization to the presentation of content (Walkington and Bernacki, 2020), and research in this area has been conducted with little involvement from education professionals, prioritizing technological aspects over pedagogical and ethical ones (Zawacki-Richter et al., 2019; Bond et al., 2024). Student-centred approaches face institutional barriers, resistance to giving students a central role, and a lack of co-design models that are scalable and transferable (Lee et al., 2018; FitzGerald et al., 2018).

In the immediate future, several challenges that warrant attention are on the horizon.

- The dual nature of generative artificial intelligence. Generative AI amplifies the possibilities at both ends of the spectrum: it enables the generation of content, feedback, and personalized assessments in real time (Guettala et al., 2024), but at the same time intensifies a central risk—that the appearance of personalization masks the absence of real learning (Mas, 2023). If students receive tailored responses without having actively engaged in the process, personalization becomes a mere simulation. This also raises questions inextricably linked to personalization that go beyond the scope of this paper: how to assess learning when it has been mediated by GAI tools, and how to distinguish what the student has learned from what the tool has produced on their behalf.

- The complexity of the educational phenomenon. Research on personalization supported by digital technologies tends to oversimplify a process that is, by nature, complex and multidimensional. Studies focusing on academic performance as an outcome variable predominate; these are conducted under controlled conditions that hardly reflect the variability of real educational contexts. This methodological reductionism limits the generalizability of the findings and overlooks relevant dimensions of learning such as self-regulation, motivation, and the social dimension. Longer-term studies, replications in diverse contexts, and metrics that go beyond standardised tests are needed.

- Equity, access, and the digital divide. AI-mediated personalized learning risks becoming a privilege if access conditions are not addressed. Its use can perpetuate or amplify existing inequalities if it is not integrated responsibly (Salinas Ibáñez and Moreno-García, 2025). Research on personalization cannot be separated from the policy decisions that determine who has access to these technologies and under what conditions.

- Ethics, algorithmic biases, and the privacy of educational data. Personalized learning requires highly sensitive data, ranging from emotional states and cognitive difficulties to attention patterns and error histories. This raises questions about privacy, informed consent, and data sovereignty that demand interdisciplinary approaches from the fields of education, law, and public policy (Salinas Ibáñez and Moreno-García, 2025). Furthermore, algorithms incorporate biases stemming from their training data that can amplify existing inequalities (Holstein and Doroudi, 2022), with a differential impact based on gender, ethnicity, socioeconomic status, or special educational needs.

- Scalability. Research on AI-driven personalized learning has been conducted primarily with small samples and in specific contexts, highlighting a marked need for longitudinal studies, more diverse designs, and larger samples (Bond et al., 2024). Scaling the results obtained under these conditions to educational systems with millions of students, teachers with widely varying levels of digital competence, and heterogeneous institutional contexts poses a major methodological and political challenge.

6. Conclusions

Personalizing learning is, first and foremost, a pedagogical issue and, ultimately, a political one. Technology expands its possibilities, but also its risks; and it does not replace the pedagogical decisions that must guide it. The tools have changed: from teaching machines to intelligent tutoring systems and language models; but the fundamental question remains how to design learning experiences that respond to the diversity of students without losing sight of the social, emotional, and reflective dimensions that are part of the learning process.

The questions that have guided this work yield answers that, rather than being definitive, help define the field. Viewed from the perspective of Educational Technology, the personalization of learning does not admit a single definition but rather a continuum ranging from system-driven adaptation to the learner's full agency. Its dimensions transcend content adaptation and include aspects such as who personalizes, what is personalized, for what purpose, and for whom. Trends are advancing simultaneously from the perspectives of technological adaptation and student agency, and both approaches face barriers that cannot be resolved with more technology. What emerges from the analysis is the need to strike a balance between the structure provided by instructional design and the autonomy required by a student capable of making decisions about their own learning.

From our perspective, this balance depends on two interdependent pedagogical conditions. The first is the ability of teachers to assume their role as designers of learning experiences that intentionally integrate technology, adapting the balance between structure and autonomy to each context. The second is the strengthening of student agency, understood as the ability to make informed decisions about their own learning process, to self-regulate, and to actively participate in the co-design of their learning. Without these two conditions, personalized learning designs are unlikely to result in learning that responds to the real needs and interests of students and the context.

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ARTICLE / ARTÍCULO

Do our university students see themselves as digital entrepreneurs?

¿Se perciben como emprendedores digitales nuestros estudiantes universitarios?

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Abstract: Competence in digital entrepreneurship is considered key for citizens in the 21st century, as it integrates entrepreneurial and digital skills necessary to face the challenges of today's society, although its development in the university environment is still an unexplored field. The aim of this article is to analyse the self-perception of digital entrepreneurship competence in university students in the last year of their Bachelor's Degree in Spanish public universities, within the framework of the EmDigital model. A quantitative, non-experimental, descriptive and correlational cross-sectional approach was used. The sample was made up of a large representation of students from different Spanish public universities, selected by stratified probabilistic sampling (N=4100). Data collection was carried out using a validated Likert-type questionnaire. The results show that students have moderate-high levels in all dimensions, with action planning standing out as the best valued, while implementation and collaboration obtain the lowest score, especially in relation to the real intention to undertake. The dimensions are moderately related to each other, which confirms their independent character within the model. Overall, the findings show a dichotomy between students' high theoretical self-perception and low practical initiative, which highlights the need to incorporate experiential learning methodologies in university education to promote the real implementation of digital entrepreneurship.

Keywords: Entrepreneurship, Competence, Higher Education, Digital Literacy, Self-perception.

Resumen: La competencia en emprendimiento digital se considera clave para la ciudadanía del siglo XXI, al integrar capacidades emprendedoras y digitales necesarias para afrontar los retos de la sociedad actual, aunque su desarrollo en el ámbito universitario sigue siendo un terreno poco explorado. El objetivo de este artículo es analizar la autopercepción de la competencia de emprendimiento digital en estudiantes universitarios de último curso de Grado en universidades públicas españolas, en el marco del modelo EmDigital. Se empleó un enfoque cuantitativo, no experimental, descriptivo y correlacional de corte transversal. La muestra estuvo conformada por una amplia representación de estudiantes de distintas universidades públicas españolas, seleccionada mediante muestreo probabilístico estratificado (N=4100). La recogida de datos se realizó mediante un cuestionario validado de tipo Likert. Los resultados muestran que el alumnado presenta niveles moderados-altos en todas las dimensiones, destacando la planificación de la acción como la mejor valorada, mientras que la implementación y colaboración obtiene la puntuación más baja, especialmente en lo relativo a la intención real de emprender. Las dimensiones se relacionan entre sí de forma moderada, lo que confirma su carácter independiente dentro del modelo. En conjunto, los hallazgos evidencian una dicotomía entre la alta autopercepción teórica y la baja iniciativa práctica del alumnado, lo que pone de manifiesto la necesidad de incorporar metodologías de aprendizaje experiencial en la formación universitaria para favorecer la implementación real del emprendimiento digital.

Palabras-clave: Emprendimiento, Competencia, Educación Superior, Alfabetización Digital, Autopercepción.

1. Introduction

Ever since the use of the internet by the general public began to expand in the 1980s and 1990s, there has been constant talk of the Digital Age. And since we began using chatbots (Generative Artificial Intelligence) in 2022, it is generally accepted that the Digital Age has given way to the Age of Artificial Intelligence (hereinafter, AI). Over the past few decades, we have experienced a rapid transformation driven by technologies that pose challenges across all spheres of society: the workplace, education, the economy, and culture. These challenges arising in our digitalized society require more complex skills related to critical and strategic thinking, communication and collaboration, leadership, innovation, and problem identification and resolution, among others. In this context, we believe that education must necessarily shift toward learning situations that are less data-centric and more competency-centric, thereby giving digital entrepreneurship a prominent role.

Digital entrepreneurship combines digital competence with entrepreneurship. On the one hand, entrepreneurship is a set of skills that—far from being merely an economic or business-oriented approach—is now viewed as an essential civic competency. It involves transforming ideas and opportunities into initiatives with social, cultural, or economic value through the development of skills that encompass creativity, autonomy, the identification of needs, and the ability to develop one's own innovative projects (Bacigalupo et al., 2016; Council of the European Union, 2018; Flores Oré, 2023). In this regard, Prendes-Espinosa and Martínez-Roig (2023) argue that educating citizens to acquire digital entrepreneurship competencies is fundamental to the progress of any society that aspires to be competitive. The Council of the European Union (2018) also identifies it as one of the basic competencies for lifelong learning. On the other hand, digital competence is understood as the ability to "use digital technologies safely, critically, and responsibly for learning, at work, and for participation in society, as well as to interact with them" (Council of the European Union, 2018, p. 9).

1.1. Digital Entrepreneurship Competency

Digital entrepreneurship links the competencies inherent to entrepreneurship with those of digital competence, which are, of course, associated with the development of technologies. Thus, digital entrepreneurship is seen as a driver of innovation and economic development (Cuadra Morales et al., 2023). Digital entrepreneurship combines entrepreneurial initiative (creativity, leadership, innovation, achievement orientation, team management, etc.) with the strategic use of digital technologies in activities that promote research and innovative solutions to problems. In other words, it involves identifying ideas and opportunities to transform them into innovative actions using digital tools that have an economic, social, or cultural impact (Allen, 2019; González-Calatayud et al., 2022; Prendes-Espinosa, 2022a; National Observatory on Technology and Society, 2023).

At the Educational Technology Research Group at the University of Murcia, we have been researching digital entrepreneurship in higher education for several years now, but we have always focused our research on the development of this competency. Our interest in entrepreneurship began with a European project on training entrepreneurs, in which—in addition to working on student training—we collected data from a sample of 272 secondary school teachers (Prendes-Espinosa et al., 2020) regarding their understanding of and approach to entrepreneurship in the classroom. These teachers stated that, in their opinion, the most important factors for training future entrepreneurs were motivation, experiential learning, and teamwork.

Subsequently, thanks to funding from the Seneca Foundation (reference 20962/PI/18), we launched the project "EmDigital: Competencies for Digital Entrepreneurship Among College Students," in which we designed a self-assessment questionnaire on digital entrepreneurship competencies for college students that was validated through a long and complex process. In the first phase, we focused on designing the conceptual model of digital entrepreneurship competence (using a comparative analysis of models, focus groups, and expert judgment).

We used the models of the European Framework as a basis (see Bacigalupo, 2022). In the case of digital competence, our reference was the DigComp model from the European Framework for Digital Competences for Citizenship. In its most recent version (DigComp 3.0), the general structure of 5 areas and 21 competencies is maintained, but aspects related to AI are systematically integrated into all competencies. It also distinguishes between explicit AI (acting directly and significantly on the competency) and implicit AI (acting in the background) (Cosgrove and Cachia, 2025). Complementing this framework is the European Framework for Digital Competence in Educators (DigCompEdu), which addresses the need for teachers to develop specific digital competencies for their professional practice (Redecker and Punie, 2017), and the DigCompOrg model for digitally competent organizations (Kampylis et al., 2015). Furthermore, in the field of entrepreneurship, the European Commission developed the European Framework for Entrepreneurial Competences (EntreComp) in 2016, structured into three areas and fifteen specific competencies (McCallum et al., 2018)—a model that was revised and expanded following a comparative analysis with other entrepreneurship models (see Prendes-Espinosa, 2022b).

Based on these frameworks for digital competence and entrepreneurial competence, the EmDigital model was developed, specifically designed to analyze digital entrepreneurial competence among college students. This model integrates the digital and entrepreneurial dimensions, breaking them down into four areas and fifteen competencies (González-Calatayud et al., 2022; Prendes-Espinosa, 2022b; Prendes-Espinosa and García-Tudela, 2020; Prendes-Espinosa et al., 2021), thus constituting one of the first attempts to operationalize both competencies in a coordinated manner within the context of higher education.

After designing the EmDigital model, a mixed-methods approach (quantitative and qualitative) was used to validate the questionnaire, following this sequence: comparative item analysis by experts; peer review; expert judgment; focus group; cognitive interviews with 19 college students; a pilot study with 190 students and AFE, yielding a Cronbach's alpha of 0.956 (see González-Calatayud et al., 2022; Prendes-Espinosa, 2022b). Following its validation, it was administered to a sample of 1,108 college students in the Region of Murcia (Prendes-Espinosa et al., 2025).

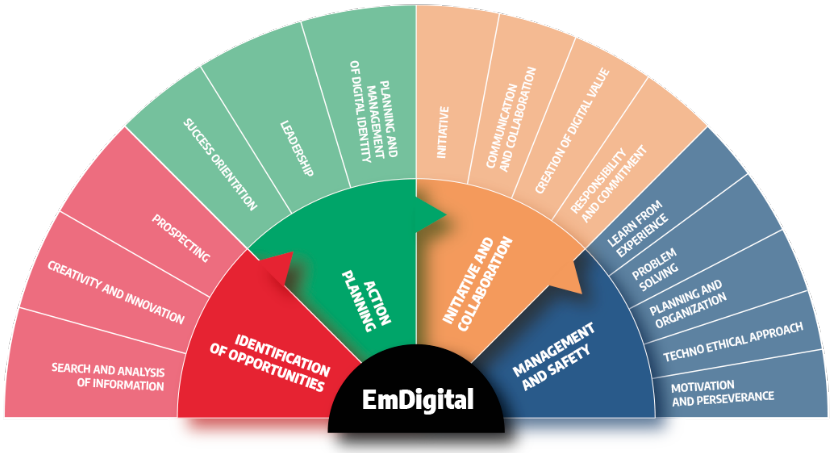

Figure 1. EmDigital Model.

1.2. Education for Digital Entrepreneurship

In the field of education, the European Commission issued the Council Recommendation of May 22, 2018, which establishes eight key competencies for the education of citizens, including digital competence and entrepreneurial competence. Both are incorporated into the Spanish curriculum (Organic Law 3/2020, of December 29, amending Organic Law 2/2006 on Education, LOMLOE) as skills that students must develop throughout the various stages of education. However, although these two competencies coexist in the national and European curriculum frameworks, there is no competency specifically named "digital entrepreneurship"' that explicitly integrates them, as we do in our proposal and our model.

Thus, the EmDigital model fills an important gap and highlights the need to move toward educational approaches that address both dimensions in a coordinated manner rather than as independent elements. Delving deeper into this idea—and specifically within the Spanish context—a study conducted in schools in the Region of Murcia revealed a gap between teachers' perceptions of ICT and its practical application: while teachers recognize the potential of these tools to stimulate creativity and collaborative work, their use to foster an entrepreneurial spirit remains limited. Among the identified causes were insufficient teacher training in entrepreneurship and a limited level of teachers' digital competence (Blázquez and Marín, 2021). This reality underscores the importance of effectively incorporating the entrepreneurial dimension into digital environments in basic education from the earliest grades, as it is a strategy to ensure that students are prepared to face the challenges of today's society.

The university setting is no exception to this reality. Although scholarly research on digital entrepreneurship at the university level remains limited (Fuentes Cabrera et al., 2024; Flores Oré, 2023), the available studies offer relevant findings. In this vein, García-Tudela et al. (2024) note that college students do not feel they have sufficient training to tackle digital entrepreneurship initiatives. Similarly, Pérez-Paredes et al. (2022) highlight a lack of confidence among Mexican college students regarding the resources, knowledge, and skills needed to become entrepreneurs. For his part, Al-

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Fattal (2024) highlights that undergraduate business students understand entrepreneurship solely from an economic perspective, without viewing it as a social phenomenon in the broader sense, and identify a lack of practical experience and knowledge as a major barrier. Along the same lines, the systematic review by Flores Oré (2023) concludes that students face difficulties related to the skills and resources needed for digital entrepreneurship.

However, other studies offer a more favorable view. Puad et al. (2025) report that university students in Malaysia self-assess their entrepreneurial and digital competencies as moderate. Similarly, Moreira-Delgado et al. (2025) find that students at the University of the Andes (Colombia) demonstrate a high level of these competencies.

Consequently, it is clear that digital entrepreneurship must be analyzed as a basic, cross-cutting competency that undoubtedly needs to be addressed in undergraduate and graduate education, as it contributes to the employability of our graduates. Our research is grounded in this perspective, approaching digital entrepreneurship from an educational rather than a business standpoint.

2. Methodology

2.1. Research Questions and Objective

We ask whether final-year undergraduate students (and thus future graduates) perceive themselves as competent in digital entrepreneurship. In other words, do they perceive themselves as capable of identifying business opportunities? Do they consider themselves capable of designing innovative proposals? Do they believe they possess leadership skills? Are they competent in managing their digital identity? Are they capable of ensuring the digital security of their proposal? These and other questions related to our EmDigital model of digital entrepreneurship seem to us to be of vital importance for designing educational programs tailored to the real needs of our future graduates. To answer them, we defined the objective of this specific phase of our research as analyzing the self-perceived competence in digital entrepreneurship among senior undergraduate students at Spanish public universities.

2.2. Research Design

This research was conducted using a quantitative approach, with a non-experimental, descriptive, and correlational cross-sectional design. This methodological design allows us, first, to characterize students' self-perceived level of digital entrepreneurial competence and, second , to establish the magnitude and direction of the bivariate relationships among the different dimensions that make up the construct, without intervention or manipulation of the study variables.

2.3. Participants and Sample

The study population consisted of university students enrolled in the final year of their respective bachelor's degree programs at public universities. To select participants, a stratified probability sampling procedure was implemented based on the total population of the participating universities. The population strata were defined based on two key structural variables: the university to which the student belonged and the field of study. As a key methodological decision, the broad academic field of Social and Legal Sciences was broken down into three independent strata (Social Sciences, Legal Sciences, and Economics). This division is justified both by the large number of students historically grouped within this category and by the marked theoretical and practical differences in educational profiles and attitudes toward entrepreneurship among these fields, since, in the university tradition, entrepreneurship has been associated very narrowly with the field of Economics.

The initial fieldwork collected a sample of 4,271 records. Following a data cleaning and quality control process, a listwise deletion criterion was applied, eliminating cases that showed a total or majority absence of responses in the survey instrument. This procedure ensured the robustness of the data matrix, resulting in a final valid sample of N=4,100 subjects.

The sociodemographic profile of the sample revealed a mean age of 22.43 years (SD=4.30). Regarding gender identity, the majority of participants identified as female (63.0%), followed by the male category (35.1%). The institutional distribution showed broad geographic coverage, with the highest representation coming from the University of Granada (30.0%), the University of Málaga (21.8%), and the University of Murcia (15.3%). The final breakdown by fields of study reflected the desired representativeness (Figure 2).

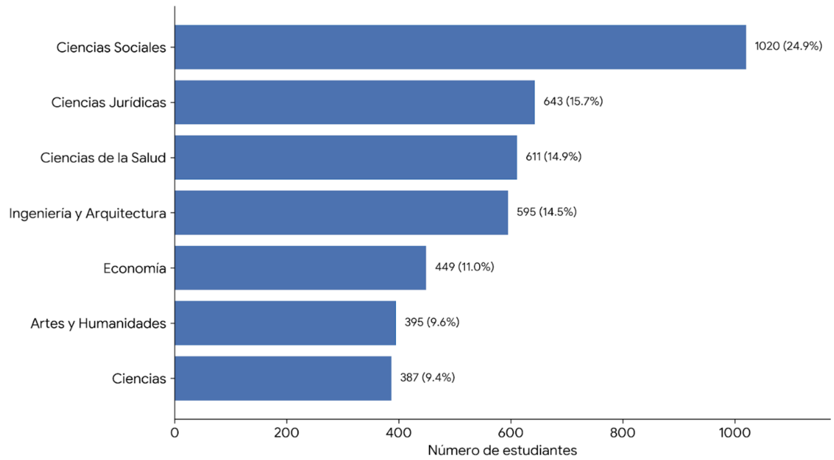

Figure 2. Distribution of the sample by fields of study.

2.4. Data Collection Instruments

To collect empirical data, the EmDigital questionnaire (González et al., 2022) was used, a validated instrument for measuring self-perceived digital entrepreneurship competence in the university setting. The questionnaire uses a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The structural model of the instrument assesses four interdependent dimensions (Figure 1 above, showing the EmDigital model): Opportunity Identification (Block 1), Action Planning (Block 2), Implementation and Collaboration (Block 3), and

Management and Security (Block 4). To confirm the psychometric properties of the scale in this specific application, internal consistency tests were conducted. The results indicated excellent overall reliability, with a Cronbach's alpha coefficient of 0.966 and a McDonald's omega coefficient of 0.973. At the di al level, Cronbach's alpha values ranged from 0.825 for Block 1 to 0.938 for Block 4. Additionally, Confirmatory Factor Analysis (CFA) yielded Composite Reliability (CR) indices that exceeded the acceptance threshold, ranging from 0.825 to 0.939 for all dimensions, thereby ensuring the measure's precision and construct validity.

2.5. Procedure

Fieldwork and data collection were conducted during the 2024–2025 academic year, specifically between September 2024 and February 2025. The questionnaire was administered entirely in digital format but was administered in the classroom with the collaboration of faculty members and through institutional channels.

The research was conducted in strict compliance with current ethical principles. The study protocol received a unanimous favorable opinion from the Research Ethics Committee of the University of Murcia (ID: 4352/2023) on February 27, 2023. Prior to participation, all subjects were informed of the research objectives and were required to provide explicit informed consent, which guaranteed voluntary participation, anonymity, and the confidential and aggregated processing of the data collected.

2.6. Data Analysis

The empirical data were processed and analyzed using advanced statistical software. In an initial analytical phase, univariate descriptive statistics (frequency distributions, percentages, arithmetic means, and standard deviations) were calculated to characterize both the sociodemographic variables and self-reported performance across the various dimensions of competence.

Prior to conducting inferential tests, the parametric assumptions of the data set were verified. Since the normality test indicated a violation of this assumption and given the ordinal-metric nature of the measurement scale, only nonparametric statistical methods were used. Consequently, to address the study's correlational objectives, Spearman's rank correlation coefficient (Rho) was calculated, allowing for an accurate assessment of the magnitude and statistical significance ($p < 0.05$) of the bivariate associations among the assessed dimensions.

3. Results

3.1. Descriptive Analysis of the Dimensions of Digital Entrepreneurial Competence

To assess participants' self-perception of their digital entrepreneurial competence, descriptive statistics for the four dimensions that make up the instrument were analyzed. Overall, the sample reported moderate-to-high levels in all areas assessed, with dimensional means ranging from 3.57 to 4.11 on a 5-point scale (Table 1).

Table 1. Descriptive statistics for the assessed dimensions.

Dimension	Minimum	Maximum	Mean (M)	Standard Deviation (SD)
Action Planning	1	5	4,11	0,78
Identifying Opportunities	1	5	3,85	0,78
Management and security	1	5	3,66	0,89
Implementation and Collaboration	1	5	3,57	0,77

Identifying Opportunities

The Opportunity Identification dimension encompasses three subcompetencies—information search and analysis, creativity, and prospecting—which together reflect the student's ability to detect, generate, and anticipate opportunities in digital environments. The results show that the sample scores above the midpoint of the scale in all three subcompetencies (Table 2), although there are substantial differences among them that warrant specific analysis.

Table 2. Subcompetencies of the Opportunity Identification dimension.

Subcompetency	M	DT	Skewness	Kurtosis
Information Search and Analysis	3,48	0,78	-0,21	-0,12
Creativity	3,24	0,96	-0,14	-0,39
Prospecting	3,86	0,81	-0,74	0,59

The prospecting subcompetency is the highest-rated in this dimension (M=3.86; SD=0.809), with a distribution clearly skewed toward high values (skewness=–0.74), indicating that most students perceive themselves as capable of anticipating trends and visualizing future scenarios. The subcompetency of information search and analysis has an intermediate mean (M = 3.48; SD = 0.776) and is the most homogeneous of the three, with the lowest standard deviation in the dimension. Within this subcompetency, the items related to the strategic search for information on the internet (M = 4.13; SD = 0.967) and the clarification of personal goals and achievements (M = 4.18; SD = 0.947) stand out in particular, both ranking among the highest scores recorded across the entire dimension.

The subcompetency of creativity, by contrast, has the lowest mean (M=3.24; SD=0.955). Its distribution is practically symmetric (skewness=–0.14), indicating high actual heterogeneity among students: profiles with a low perception of their creative ability coexist with those who rate themselves highly. This variability is particularly evident in the item that assesses the current possession of specific innovative ideas likely to be realized in the future (M = 3.04; SD = 1.119), the lowest score in the entire dimension and the only one that approaches the midpoint of the scale.

Action Planning

The Action Planning dimension received the highest overall score in the entire model, with all three subcompetencies scoring above M = 3.85 in every case, distinguishing it as the dimension with the highest level of self-perceived competence in the sample (Table 3).

Table 3. Subcompetencies of the Action Planning dimension.

Subcompetency	M	DT	Skewness	Kurtosis
Achievement orientation	4,21	0,72	-1,21	1,5
Leadership	3,85	0,78	-0,68	0,45
Digital Identity Planning and Management	3,87	0,8	-0,6	0,1

The "achievement orientation" sub-competency is the highest-rated within this dimension and across the entire model (M = 4.21; DT = 0.724), with a markedly asymmetric distribution toward high values (skewness = –1.21) and high positive kurtosis (1.50), indicating that responses are concentrated at the higher end of the scale with little dispersion. The items regarding the importance of effective teamwork for a project's success (M = 4.44; SD = 0.841) and the usefulness of digital technologies in project design (M = 4.41; SD = 0.877) are among the highest scores recorded across the entire scale. The low standard deviation of the subcompetency (SD = 0.724) reflects a high degree of homogeneity in the sample's responses.

The subcompetency of digital identity planning and management shows a high mean (M = 3.87; SD = 0.800) with a moderate negative distribution (skewness = –0.60), indicating a general tendency toward scores above the midpoint. The kurtosis close to zero (0.10) indicates an approximately mesokurtic distribution, with no notable concentration at the extremes. This subcompetency reflects students' ability to organize and project their presence and identity in digital environments for professional or entrepreneurial purposes.

The leadership subcompetency has the lowest mean score in the dimension (M = 3.85; SD = 0.780), although it remains at a medium-high level. Its distribution is negatively skewed (skewness = –0.68) with moderate positive kurtosis (0.45), indicating some concentration of responses at higher values, albeit with greater relative dispersion than achievement orientation. It is the subcompetency with the greatest variability within the dimension, along with digital identity planning and management.

Implementation and Collaboration

The Implementation and Collaboration dimension had the lowest overall score in the model, with greater variability among subcompetencies than in the previous dimensions and containing the item with the lowest score and greatest dispersion in the entire instrument (Table 4).

Table 4. Subcompetencies of the Implementation and Collaboration dimension.

Subcompetency	M	DT	Skewness	Kurtosis
Initiative	3,16	0,98	-0,1	-0,48
Communication and Collaboration	3,62	0,79	-0,46	0,04
Digital Value Creation	3,59	0,88	-0,45	-0,16
Responsibility and Commitment	3,88	0,77	-0,54	-0,02

The sub-competency of responsibility and commitment is the highest-rated in this dimension (M=3.88; SD=0.773), with a moderately negative skew (skewness=–0.54) and a kurtosis close to zero (–0.02), indicating a relatively symmetrical distribution around medium-to-high values. Within this subcompetency, the item referring to respectful behavior online stands out, obtaining one of the highest scores in the entire instrument (M=4.33; SD=0.918), with a virtually unanimous response at the higher end of the scale.

The communication and collaboration subcompetency ranks second (M = 3.62; SD = 0.785), with moderate negative skewness (–0.46) and kurtosis close to zero (0.04), reflecting a balanced distribution centered on medium-to-high values and a homogeneous dispersion among participants.

The "digital value creation" subcompetency scored an average of 3.59 (SD = 0.884), with a negative skewness (–0.45) and a slightly negative kurtosis (–0.16), indicating a somewhat flatter distribution than the previous ones and, therefore, greater relative variability in the responses. It is the subcompetency with the second-highest dispersion in the dimension.

The "initiative" subcompetency has the lowest score in the entire dimension and one of the lowest in the model (M=3.16; SD = 0.977), with a nearly symmetric distribution (skewness = –0.10) and negative kurtosis (–0.48), indicating a flattened distribution with responses distributed heterogeneously across the scale. This subcompetency includes the item with the lowest score in the entire instrument, which refers to the actual intention to create a digital entrepreneurship project in the future (M = 2.80; SD = 1.228); it is also the item with the greatest dispersion on the entire scale, indicating a notable polarization in participants' responses.

Management and Security

The Management and Security dimension groups five sub-competencies ranging from the ability to learn from experience and solve problems to ethical awareness and the motivation to sustain effort over time. The mean values for the five sub-competencies range from 3.60 to 3.71, making this the most homogeneous dimension of the model in terms of the distance between sub-competencies (Table 5).

Table 5. Subcompetencies of the Management and Safety dimension.

Subcompetency	M	DT	Skewness	Kurtosis
Learning from experience	3,71	0,78	-0,51	0,33
Troubleshooting	3,63	0,75	-0,4	0,24
Planning and Organization	3,6	0,77	-0,31	-0,04
Techno-ethical vision	3,65	0,8	-0,47	0,22
Motivation and Perseverance	3,6	0,82	-0,39	-0,04

The sub-competency of learning from experience has the highest mean score in the dimension (M=3.71; SD=0.777), with a moderately negative skew (skewness=–0.51) and mild positive kurtosis (0.33), indicating a concentration of responses in the higher values with few extremely low scores.

The "techno-ethical vision" subcompetency ranks second (M = 3.65; SD = 0.798), with a negative skewness (–0.47) and moderate positive kurtosis (0.22). Within this subcompetency, the items related to the need to meet established deadlines (M = 4.18; SD = 0.956) and to ensuring the protection of personal data (M = 4.07; SD = 1.000) stand out, both ranking among the highest in the dimension, reflecting a high level of regulatory and ethical awareness among participants. In contrast, items referring to the use of ICT as a tool to ensure digital security received significantly lower scores (M=3.33; SD=1.137), with the greatest dispersion recorded in this subcompetency, indicating a gap between awareness of the importance of security and self-perceived technical proficiency in ensuring it.

The problem-solving subcompetency has a mean of 3.63 (SD = 0.747) with a moderately negative skewness (–0.40) and mild positive kurtosis (0.24); it is the subcompetency with the lowest dispersion across the entire dimension, reflecting a relatively uniform assessment among participants.

The planning and organization subcompetency has a mean of 3.60 (SD = 0.771), with a negative skewness (–0.31) and slightly negative kurtosis (–0.04), indicating a distribution that is practically mesokurtic with a slight tendency toward higher values on the scale.

The subcompetency of motivation and perseverance has the lowest mean in the dimension (M = 3.60; SD = 0.822), with a moderately negative skewness (–0.39) and a kurtosis close to zero (–0.04). It is also the subcompetency with the greatest dispersion within the dimension, suggesting greater heterogeneity among participants in their perception of their ability to sustain effort and motivation over time.

3.2. Relationship Among the Dimensions of Entrepreneurial Competence

To examine the interdependence among the different dimensions assessed, a bivariate correlation analysis was conducted using Spearman's Rho coefficient. The findings reveal the existence of positive and statistically significant correlations ($p < 0.001$) among all the dimensions that make up the construct. The strongest association is observed between the Management and Security dimension and the Implementation and Collaboration dimension (Rho = 0.431), followed closely by the relationship between Management and Security and Opportunity Identification (Rho = 0.422). In contrast, the weakest correlation—though still significant—is found between Action Planning and Implementation and Collaboration (Rho = 0.257).

From a theoretical perspective, the presence of moderate-to-low correlations (ranging from 0.257 to 0.431) is consistent with a multidimensional model. These values indicate that, while the four dimensions share an underlying basis and reinforce one another—that is, greater proficiency in technical management or planning is associated with a greater ability to identify opportunities and engage in collaborative initiatives—they operate as empirically distinct facets. The absence of excessively high correlations (greater than 0.80) rules out multicollinearity issues and confirms that each dimension contributes unique variance to the model, justifying their independent evaluation within the framework of digital entrepreneurial competence.

4. Discussion

The main objective of this study was to analyze university students' self-perception of digital entrepreneurial competence by examining its constituent dimensions. The results reveal a fundamental dichotomy in the student profile: while there is a high perception of competence in theoretical and strategic phases, there is a significant lack of intent to actually execute.

On the one hand, the dimensions of Action Planning and Opportunity Identification received the highest ratings. College students perceive themselves as highly capable of seeking strategic information online and recognize the value of technology-mediated teamwork. These findings are consistent with this demographic's status as heavy users of digital environments (National Observatory of Technology and Society, 2023). However, this instrumental mastery does not automatically translate into entrepreneurial initiative. The "Implementation and Collaboration" dimension received the lowest score in the model, with the statement regarding the actual intention to create a digital entrepreneurship project in the future being the item with the lowest score and greatest variation.

These findings are closely aligned with the research by García-Tudela et al. (2024) and Pérez-Paredes et al. (2022), who had already noted that college students lack the confidence and practical training necessary to bring entrepreneurial proposals to fruition. Similarly, they confirm the conclusions of Flores Oré (2023) regarding students' difficulties in moving from the conceptualization of ideas to the mobilization of resources. Although international studies such as those by Puad et al. (2025) or Moreira-Delgado et al. (2025) report moderate-to- ly high levels of general entrepreneurial competencies, the results of this study qualify this view: students feel theoretically prepared but lack the practical initiative (agency) to execute real projects.

From a theoretical and inferential perspective, Spearman's correlation analysis supports the multidimensional nature of the EmDigital model (Prendes-Espinosa and García-Tudela, 2020). The positive and moderate correlations demonstrate that the dimensions are interrelated but are independent constructs. This empirical finding is crucial for the social sciences and pedagogy: it confirms that digital competence (knowing how to use tools or manage security) does not, on its own, generate entrepreneurial competence (initiative and implementation). As Blázquez and Marín (2021) point out, technological integration without an entrepreneurial approach is insufficient.

5. Conclusions and future research

The implications of these findings for higher education are clear. Universities must not limit themselves to offering purely instrumental or theoretical training; it is imperative to promote experiential learning ecosystems. As the faculty members noted in the study by Prendes-Espinosa et al. (2020), motivation and practical experience are the true drivers of entrepreneurship. Therefore, university curriculum development must integrate digital entrepreneurship competencies across all disciplines, facilitating idea incubators, active methodologies (such as Project-Based Learning or Collaborative Learning), and simulations that reduce the fear of failure and encourage the actual implementation of solutions to social and economic problems.

Among the limitations of this study, it is worth noting the use of a self-report instrument, which may be subject to social desirability bias or an overestimation of theoretical abilities. As future lines of research stemming from the MAEDU project, it will be necessary to conduct multivariate inferential analyses that cross-examine these dimensions with sociodemographic variables (such as field of study or gender), as well as cross-referencing this data with the perceptions of university faculty (EmDigital-Prof) and organizational policies (EmDigital-Org), to obtain a systemic overview that will enable the optimization of training for future graduates.

This research will be completed in subsequent phases with the analysis of data on faculty (EmDigital-Prof) and institutions (EmDigital-Org), information that will allow us to visualize, in an integrated and comprehensive manner, how digital entrepreneurship is being addressed at Spanish public universities. The purpose of defining this framework is to provide recommendations for the design of university education, taking into account the core competencies of degree programs. We also aim to design self-assessment and diagnostic tools. As for future projects, we are interested in expanding the research to include pre-university levels.

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ARTICLE / ARTÍCULO

Creating AI Applications for EFL Teaching: Perceptions and Challenges in Initial Teacher Education

Crear aplicaciones con IA para enseñar inglés: percepciones y desafíos en formación inicial docente

Roxana Rebolledo-Font de la Vall[1] & Mercè Gisbert-Cervera[2]

Abstract: The dimension of "creating" with artificial intelligence (AI), proposed by UNESCO as an advanced level of AI literacy, remains underexplored in the field of initial teacher education (ITE), particularly in English as a foreign language (EFL) teaching. In this context, the present study aimed to analyze pre-service English teachers' perceptions of the pedagogical possibilities and difficulties associated with creating educational applications using generative AI (GenAI) through Gemini 3.0. The participants were 51 English Pedagogy students from three Chilean public universities. The study adopted a qualitative approach through an online form, and the data were analyzed using inductive content analysis based on Krippendorff's model, with the assistance of two large language models and human supervision. The results were organized into five categories: the pedagogical potential of AI for English language learning, the creation of educational applications, the new role of the pre-service teacher, new competencies and challenges in the use of AI, and the appropriation of the experience. However, an important finding was the identification of specific training gaps: prompt formulation emerged as a didactic competence rather than a technical one, and the greatest difficulty lay in translating pedagogical intentions into clear instructions. The experience also transformed pre-service teachers' self-perception, as they came to see themselves as creators of educational technology. It is concluded that initial teacher education must shift the focus from the tool to the pedagogical problem, preparing teachers as learning sequence designers who create, adapt, and critically evaluate AI-powered resources.

Keywords: Artificial Intelligence, English as Foreign Language, Pre-service Teachers, Educational Technology, Technology uses in Education.

Resumen: La dimensión de «crear» con inteligencia artificial (IA), propuesta por la UNESCO como nivel avanzado de alfabetización en IA, está poco explorada en el ámbito de la formación inicial docente (FID), especialmente en el área de la enseñanza del inglés como lengua extranjera (ILE). En este contexto, el presente estudio tuvo como objetivo analizar las percepciones de futuros docentes de inglés sobre las posibilidades pedagógicas y las dificultades asociadas a la creación de aplicaciones educativas con IA generativa (IAGen) utilizando Gemini 3.0. Participaron 51 estudiantes de Pedagogía en Inglés de tres universidades públicas chilenas. La investigación adoptó un enfoque cualitativo mediante la aplicación de un formulario en línea, y los datos fueron analizados mediante un análisis de contenido inductivo basado en el modelo de Krippendorff, con asistencia de dos modelos de lenguaje de gran escala y supervisión humana. Los resultados se organizaron en cinco categorías: potencial didáctico de la IA para el aprendizaje del inglés, creación de aplicaciones educativas, nuevo rol del futuro docente, nuevas competencias y desafíos en el uso de la IA. No obstante, un hallazgo importante fue la identificación de vacíos formativos concretos: la formulación de prompts emergió como una competencia didáctica, no técnica, y la mayor dificultad radicó en traducir intenciones pedagógicas en instrucciones claras. La experiencia también transformó la autopercepción de los futuros docentes, quienes se reconocieron como creadores de tecnología educativa. Se concluye que la formación inicial docente debe desplazar el foco de la herramienta al problema pedagógico, preparando a los profesores como diseñadores de secuencias de aprendizaje que crean, adaptan y evalúan críticamente recursos con IA.

Palabras-clave: Inteligencia artificial, Inglés como lengua extranjera, Futuros docentes, Tecnología educativa, Usos educativos de la tecnología.

1. Introduction

Given the changes brought about by the emergence of GenAI in university classrooms, from methodologies to institutional policies (An et al., 2025; Cacho, 2024), it is necessary to investigate how these tools are currently being integrated into the curriculum for the preparation of pre-service teachers of English as a foreign language (EFL). Although the influence of computer-assisted language learning (CALL) has been studied since the 1960s and 1970s (Patahuddin et al., 2024), followed later by intelligent computer-assisted language learning (Weng & Chiu, 2023), the current scenario poses different challenges. GenAI far exceeds the possibilities of earlier intelligent tutoring systems, both because of its greater processing capacity and because of the possibility of interacting through natural language. This shift marks a turning point in teacher education, as it expands the ways in which pre-service teachers can design, adapt, and evaluate learning experiences. In this context, it is essential to analyze the challenges faced by ITE in relation to these technologies, as well as to define educational policies aimed at developing AI competencies that consider their technical, pedagogical, ethical, and human dimensions (Miao et al., 2021).

To guide this study, the following research questions were posed:

RQ1. How do pre-service English teachers perceive the pedagogical possibilities of AI for creating applications aimed at EFL teaching?

RQ2. What difficulties do they face during the process of creating educational applications with GenAI?

Answering these questions contributes to the discussion on the role of GenAI in initial teacher education, especially in relation to the transition from the instrumental use of digital tools to the creation of interactive resources with pedagogical intentionality. In addition, the study provides situated evidence on a still-emerging practice in the Latin American context: the use of generative AI to prototype educational applications aimed at learning English as a foreign language.

The purpose of this study is to generate findings that contribute to strengthening initial teacher education in English, particularly in relation to pre-service teachers' familiarization with GenAI tools. In this case, the activity focused on the use of Google Gemini 3.0 to create educational applications aimed at solving learning difficulties identified by the ITE students themselves.

1.1. The New Role of the Teacher in the Age of AI

UNESCO defines AI competence as the knowledge, skills, values, and attitudes that people need to develop to integrate AI effectively and ethically into educational processes (Ahmad et al., 2025).

The AI Competency Framework for Teachers (AI-CFT) defines the principles, values, knowledge, and critical skills teachers need to understand the role of AI and use it ethically, effectively, safely, and responsibly (Miao & Cukurova, 2025). The framework warns that formal education tends to respond reactively to the widespread adoption of AI across all areas of human development. It therefore proposes a paradigm shift, in which public education is not a space of passive adoption but rather a means of empowering future leaders who can shape AI (Mikeladze et al., 2024; Zainuddin et al., 2025). UNESCO proposes three levels of progression in the AI-CFT: acquire, deepen, and create. Together, these levels show that teachers' professional development begins with a basic understanding of AI, advances toward its responsible and pedagogical use, and culminates in the ability to transform educational practice through creation with AI.

In the present study, the "create" level is especially relevant because it allows for an analysis of the transition from the functional use of AI tools to AI-mediated pedagogical design practices (Bai, 2025; Dou & Zhao, 2025) (see Figure 1).

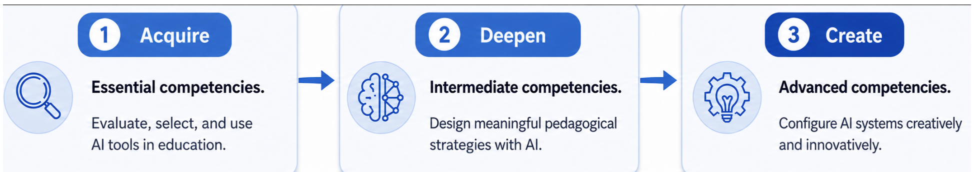

Figure 1. Levels of AI competence for teachers according to UNESCO's AI Competency Framework for Teachers (AI-CFT).

This framework also includes five domains: human-centered mindset, AI ethics, foundations and applications, AI pedagogy, and professional development (Chiu et al., 2025). In each domain, teachers move from initial knowledge and the basic use of tools toward a critical and ethical integration of AI aimed both at improving students' learning and transforming their own practice.

1.2. The New Role of the Student in the Age of AI

UNESCO has also developed an AI Competency Framework for Students (AI-CFS) with the purpose of guiding education systems in defining what students should know, value, and be able to do in relation to AI (Miao et al., 2025). Recent research is beginning to apply and validate this framework across different countries, educational levels, and disciplines.

This framework organizes learning around four dimensions: a human-centered mindset, AI ethics, foundations, techniques, and applications of AI system design (Wang et al., 2026). Each of these domains includes progression stages that move from initial understanding to the creation of AI-based solutions. This progression is structured across three levels: understand, apply, and create, which makes it possible to visualize the development of increasingly complex, critical, and productive AI literacy.

This idea of progression is relevant to the present study because the participants occupy a dual position: they are university students and, at the same time, pre-service English teachers. Therefore, the experience of creating applications with AI can be interpreted both as an AI literacy activity for students and as an initial pedagogical design practice for their future professional performance.

Beyond the instrumental use of AI tools, the AI-CFS proposes that students develop the capacity to act with autonomy, responsibility, and ethical awareness. In addition, they should understand the foundations of AI, apply it in concrete situations, and advance toward the creation of tools or solutions through processes of design, testing, feedback, and continuous improvement.

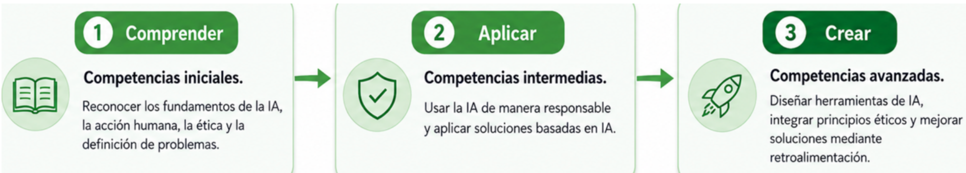

Figure 2. Levels of AI competence for students according to UNESCO's AI Competency Framework for Students (AI-CFS).

Figure 2 illustrates the three-level progression that guides the development of students' AI literacy, moving from the recognition of foundations to the design and improvement of AI-based solutions through continuous feedback processes.

Recent studies show that students tend to adopt AI more frequently and experimentally than educators, particularly for autonomous learning, brainstorming, and overcoming language barriers (Chan & Hu, 2023; Wang & Li, 2024). Educators, by contrast, tend to be more cautious and express concerns about academic integrity, the quality of generated content, and its pedagogical relevance (Francis et al., 2025).

In conclusion, the AI-CFT and AI-CFS coincide in emphasizing that both teachers and students should be able to use AI to create. This means moving away from a passive use of AI and toward active improvement and involvement in the teaching and learning process (Zhao et al., 2026).

1.3. Creation of Personalized Instructional Material

To move from UNESCO's global vision to the practical reality of the classroom, it is necessary to understand that the advanced competence of "creating" with AI requires a profound change in the self-perception of both in-service and pre-service teachers. This change involves moving from the role of mere "consumers of digital resources" toward that of "creators of educational technology." However, this level of competence only becomes meaningful when it is translated into concrete classroom decisions: what to design, for whom, with what objective, and according to which pedagogical criterion.

The creation of instructional materials by teachers is an activity that must be continuously planned and implemented in order to guide students' learning process. Since the pandemic, teachers were forced to integrate digital technologies rapidly, without prior training and through trial-and-error processes. This situation led them to learn, almost in real time, how to teach online, use virtual platforms, and devote a significant amount of time to preparing instructional support resources (Ramakarsinin et al., 2022). In this context, GenAI emerges as an alternative for responding to these demands, since it can support both the production of resources and the design of activities more closely aligned with students' needs.

GenAI can help produce personalized multimodal materials (text, images, audio, and videos), reducing teachers' workload in preparation and correction (Ruiz-Rojas et al., 2023; Yuan et al., 2025). It can also support students' learning process by creating adaptive lessons and assessments, allowing greater flexibility by adjusting content to each participant's level of progress (Pesovski et al., 2024).

The creation of educational applications through GenAI is not merely a technical activity, but a complex pedagogical practice that requires pre-service teachers to translate learning needs into instructions, prototypes, activities, feedback mechanisms, and criteria for didactic adequacy. Consequently, prompting is not understood merely as a technical skill for communicating with a tool, but as an emerging didactic competence (Federiakin et al., 2024). Formulating a prompt to create an educational application involves defining learning objectives, anticipating students' characteristics, selecting linguistic content, deciding types of interaction, and anticipating forms of feedback. From this perspective, the quality of the generated product depends both on the tool used and on the pedagogical judgment of the pre-service teacher.

Although many teachers use digital technologies in their educational practices, the creation of their own content remains one of the weakest areas of their digital competence (Kiryakova & Kozhuharova, 2024). This difficulty points to the need to strengthen formative experiences oriented toward the design and creation of digital educational resources with clear pedagogical criteria.

This same difficulty in creating one's own resources also extends to the field of artificial intelligence, where pre-service teachers' perceptions and attitudes play a key role in their willingness to integrate AI into the classroom.

1.4. Pre-Service Teachers' Perceptions of the Use of AI in EFL Teaching

Recent research in contexts such as Europe, Asia, and Latin America shows that pre-service teachers of English as a foreign language (EFL) perceive GenAI as a pedagogically useful tool, although they also recognize certain risks that require specific training and critical use (Pokrivcakova, 2023; Rebolledo et al., 2025; Taşçı & Tunaz, 2024). In line with this trend, Harakchiyska's (2025) study in Bulgaria reveals that knowledge of AI and competence in teaching with the support of this technology are key indicators of pre-service teachers' readiness to integrate it into their future English classes, which evidences a favorable attitude toward its pedagogical adoption.

Nevertheless, although pre-service teachers show mostly positive attitudes toward the integration of AI into English teaching and consider that it can improve learning processes, they also recognize important limitations. These include their limited technical knowledge of AI, as well as the perception that they lack the skills and do not feel sufficiently competent to use it for pedagogical purposes (Derinalp & Halife, 2025; Harakchiyska & Vassilev, 2024). These shortcomings point to the urgent need to update teacher education curricula in order to foster consistent AI literacy among pre-service foreign language teachers, a change that requires the support of policymakers, university program designers, and teacher education providers.

Although the literature reports favorable attitudes toward AI and the need for training, there is still limited evidence on real creation experiences with GenAI among pre-service EFL teachers (Law, 2024). To help fill this gap, this study aimed to explore pre-service English teachers' perceptions of the pedagogical possibilities and challenges associated with an experience of creating educational applications with Gemini 3.0 GenAI for EFL teaching.

1.5. Study Context

The activity was carried out asynchronously within the framework of a broader formative experience on the use of AI to support academic writing in English. Following a pilot study conducted in 2024, the proposal was redesigned by incorporating a session focused on creating educational applications with GenAI. This implementation made it possible to observe how pre-service teachers transformed learning needs into objectives, didactic decisions, and instructions for the tool.

2. Methodology

The study adopted a qualitative design aimed at exploring pre-service English teachers' perceptions of creating educational applications with GenAI. The applications generated through Gemini 3.0 were understood as interactive digital teaching resources designed to support specific language skills.

2.1. Research Design

The study was framed within a qualitative design aimed at exploring pre-service English teachers' perceptions of the use of AI for creating educational applications. To analyze the evidence, the content analysis method based on Krippendorff's (1989) original model was used, adapted for application with AI assistance (Longo, 2020; Maj et al., 2025). As detailed in Section 2.4, this method made it possible to extract meaning from the textual corpus through a reliable, repeatable, and systematic process (Krippendorff, 2019).

2.2. Participants

The study participants were students of English Pedagogy as a foreign language, who were asked to generate applications using Gemini 3.0 and report on their experience. The study focused on an intentional and diverse sample, considering variables such as university of origin, gender, year of study, and level of English proficiency.

The final group consisted of 51 students from three Chilean public universities, anonymized as U1 (northern zone), U2 (central zone), and U3 (southern zone). It is important to note that this description serves a strictly contextual purpose; the study did not aim to conduct statistical comparisons based on these variables. To contextualize the sample, Figure 3 presents a descriptive characterization of the participants according to university of origin, gender, declared English level, and year of study.

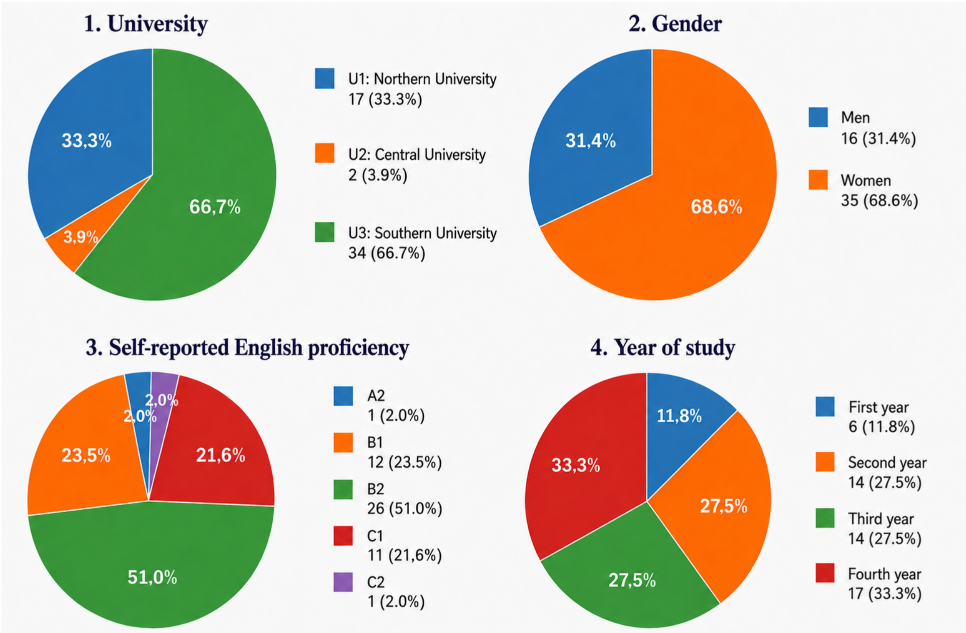

Figure 3. Profile of the study participants.

Figure 3 presents the distribution of the 51 pre-service English teachers according to university of origin, gender, declared English level, and year of study. These data are included for descriptive purposes to contextualize the sample, since the study did not aim to compare perceptions according to these variables.

2.3. Ilnstrument and Data Collection Procedure

Data were collected using a structured activity and reflection form specifically designed for the training session. This form integrated informed consent, participant characterization data, step-by-step instructions for creating an educational application with Gemini Canvas, an instructional video, registration questions about the designed app, and a final open reflection section. In this final section, pre-service teachers could respond in English or Spanish to guiding questions about the pedagogical possibilities of AI, the difficulties faced during the process, and the possible use of these applications in real EFL teaching contexts. Since the form was not intended to measure a construct through standardized scales, but rather to guide a formative activity and collect open-ended perceptions, it was not subjected to a formal psychometric validation process; however, its design responded directly to the objectives of the session and the study's research questions[1].

2.4. Data Analysis Technique

The inductive content analysis followed Krippendorff's (1989) model. After an initial reading of the corpus, AI-assisted coding was carried out using two LLMs—ChatGPT 5.5 and Claude Sonnet 4.6—which analyzed the same anonymized corpus through a common prompt. The outputs generated were contrasted by the research team, which reviewed, merged, discarded, or reformulated categories according to their relevance

[1] The data used in this study are available in the following repository: https://doi.org/10.5281/zenodo.20402853

to the research questions. Therefore, the final analysis does not correspond to an automatic output, but to a human interpretation supported by AI (Jiang et al., 2025). This process of interpretive construction, which integrated the assistance of LLMs with the supervision of the research team, is illustrated schematically in Figure 4.

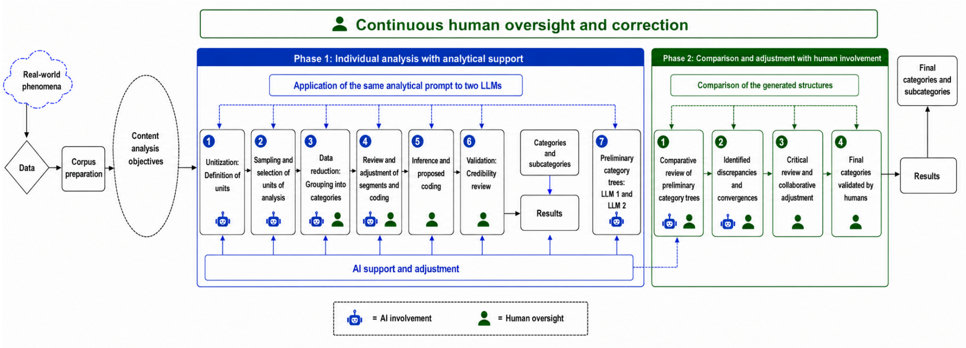

Figure 4. AI-assisted content analysis with human supervision based on the phases of Krippendorff's model.

Figure 4 describes the AI-assisted content analysis workflow, grounded in Krippendorff's (1989) classical methodology and complemented by the protocol for implementing generative AI proposed by Goyanes and De-Marcos (2025). The workflow is structured in six fundamental stages: unitization, sampling, data reduction, review and adjustment, inference, and validation (Phase 1).

To implement this workflow, the analysis was organized into a sequential seven-step procedure, which required two different types of instructions for the language models.

2.5. Prompts Given to the AI Tools

To carry out the content analysis and subsequently the comparison and triangulation of the data obtained, two prompts were created. The first was an analytical prompt and the second a comparative prompt[2].

2.6. Ethical Approval and Informed Consent

The favorable decision certified that the proposal complied with all corresponding methodological, ethical, and legal requirements, including the principles of good scientific practice, data privacy, confidentiality, and respect for human rights[3].

3. Results

The content analysis made it possible to organize pre-service English teachers' perceptions into five main categories: the pedagogical potential of AI for English learning, the creation of educational resources and applications with AI, the

[2] Due to their length, the two prompts are available as an annex document in the following repository: https://doi.org/10.5281/zenodo.20402522

[3] This research was approved by the ethics committee of the corresponding institution: https://doi.org/10.5281/zenodo.20282219

pedagogical role of the pre-service teacher in AI-based design, competencies and challenges for the use of generative AI, and appropriation of the experience and change in perception. Taken together, these categories show that creating applications with GenAI was not perceived merely as a technical activity, but as a formative experience that led participants to rethink the design of resources, the personalization of learning, and their own role as pre-service English teachers.

Table 1. Pre-service English teachers' perceptions of creating educational applications with AI.

Categories	Subcategories
1. Pedagogical potential of AI for English learning	1.1 Personalization and adaptation of learning
	1.2 Immediate feedback and autonomous practice
	1.3 Interactivity, motivation, and gamification
	1.4 Contextualized and self-paced practice
2. Creation of educational resources and applications with AI	2.1 Creation of applications, games, and teaching resources
	2.2 Design oriented toward real learning needs
	2.3 Feasibility of use in real educational contexts
	2.4 Accessibility for creating without knowing how to program
3. Pedagogical role of the pre-service teacher in AI-based design	3.1 Pedagogical decision-making
	3.2 Definition of objectives, audience, and context
	3.3 AI as support and not as a replacement for the teacher
	3.4 Reconceptualization of the teaching role
4. Competencies and challenges for the use of generative AI	4.1 Formulation of prompts and precise instructions
	4.2 Cognitive complexity of AI-based design
	4.3 Technical difficulties, access, and functionality
	4.4 Need for critical and reflective integration
5. Appropriation of the experience and change in perception	5.1 Surprise and discovery of new possibilities
	5.2 Empowerment and teacher agency
	5.3 Ease, speed, and time saving
	5.4 Limited understanding, dependence, or need for guidance

The categories and sub-categories presented in Table 1 correspond to an interpretive synthesis developed by the research team based on the comparison of the two categorical trees generated by the two LLMs[4].

[4] Due to their length, they are published in the following repository: https://doi.org/10.5281/zenodo.20402205

Table 2. Examples of applications created.

No.	Content	Identification	Pedagogical characterization	Public link
13	Vocabulary	Code: U2-S2 App: Bug Buddies	Difficulty addressed: Academic vocabulary and pronunciation Audience: Elementary	https://gemini.google.com/share/b3831b5e983b
22	Pronunciation and phonetics	Code: U3-S14 App: TimeWise: Prepositions Trainer	Difficulty addressed: Grammar accuracy and usage (prepositions of time) Audience: University	https://gemini.google.com/share/7da580ebc46e
24	Listening comprehension	Code: U3-S15 App: Listening Master	Difficulty addressed: Listening practice Audience: Secondary	https://gemini.google.com/share/66ce5704f77a
27	Writing and production	Code: U3-S6 App: Stories to Life	Difficulty addressed: Grammar and vocabulary accuracy Audience: Elementary	https://gemini.google.com/share/c004a8def812
29	Oral communication and conversation	Code: U3-S1 App: FluentFlow	Difficulty addressed: Pronunciation, grammar, and vocabulary use Audience: Adult	https://gemini.google.com/share/dddc6c50428c
32	Exam preparation	Code: U3-S18 App: LexiconC1	Difficulty addressed: Acquiring and actively using advanced C1 vocabulary Audience: University / Secondary	https://gemini.google.com/share/669426e4cc18
34	Multicompetence / integrated	Code: U1-S7 App: LingoQuest	Difficulty addressed: Grammar, vocabulary, and communication Audience: Mixed	https://gemini.google.com/share/b005b28371b5

Table 2 groups the main categories on which students focused when creating the apps. Each record includes an identification, a brief pedagogical characterization, and the public link to the application. Overall, the table evidences the diversity of solutions designed by the participants, who not only generated interactive digital resources but also oriented their applications toward concrete needs in English learning, such as academic vocabulary practice, grammatical use, listening comprehension, written production, or oral interaction. This reinforces the idea that the activity of creation with AI fostered a practical approach to AI-mediated didactic design[5].

[5] Although not all digital products generated by the pre-service teachers remained available through functional public links, an annex repository has been made available at https://doi.org/10.5281/zenodo.20367815, which includes access to 34 applications, the prompts used to create them, and their linguistic level.

4. Discussion and Conclusions

A relevant contribution of this study is that it made it possible to empirically verify that the creation of educational applications with GenAI is not limited to a positive evaluation of the tool but rather enables the identification of concrete training gaps in ITE. The results offer a useful diagnosis for university English Pedagogy programs, showing which competencies need to be strengthened so that pre-service teachers can move from an instrumental use of AI toward more advanced instructional design practices.

The findings are characterized by a progression from instrumental uses of GenAI toward more complex practices of design, creation, and evaluation of educational resources. This shows that AI was resignified by the participants as a tool for pedagogical production. However, this possibility depends on emerging competencies related to prompt design, the definition of pedagogical objectives, the selection of relevant functions, and the critical supervision of the products generated.

The study dialogues with international AI competency frameworks, while also contributing a situated perspective from Latin American ITE, where technological innovation must be analyzed alongside conditions of access, cultural relevance, teacher agency, and ethical and pedagogical criteria for creating with AI.

Based on the five findings organized in Table 1, the study suggests that ITE should move from a tool-centered approach toward an approach centered on the pedagogical problem. It is not enough to tell students: “here is the tool, learn how to use it”; it is more formative to ask: “what pedagogical problem can you solve with it?” This shift in focus makes it possible to prepare pre-service teachers as designers of learning sequences who can create, adapt, review, and evaluate digital resources with pedagogical meaning.

The results show a predominantly positive perception regarding the pedagogical possibilities of AI for creating English-learning applications. Participants valued the possibility of designing resources adapted to specific needs, “the personalization of learning, immediate feedback, and the creation of more dynamic activities” (U3-S3). This finding is consistent with recent literature that highlights the potential of GenAI to support personalization, feedback, and more flexible learning experiences (Law, 2024; Pesovski et al., 2024; Weng & Chiu, 2023). However, the specific contribution of this study lies in the fact that it does not analyze only the use of AI by students to learn English, but rather the experience of pre-service teachers creating educational applications. This makes it possible to observe a more complex dimension: AI not merely as support for learning, but as a mediator of didactic design.

Table 2 shows that participants did not create applications in a generic way, but rather oriented them toward specific difficulties: academic vocabulary, grammatical use, listening comprehension, writing, oral communication, exam preparation, and the integrated development of skills. The audiences were diverse (elementary, secondary, university, and adult learners). This demonstrates that the activity required pre-service teachers to make deliberate initial pedagogical decisions about what difficulty to address, for whom to design, and what type of support to provide.

A particularly relevant aspect is that the experience enabled some participants to recognize themselves as potential creators of educational technology. The statement "I do not need to be a professional software engineer to create interactive learning tools; I can move from being a textbook reader to a creator of personalized applications" (U3-S14) evidences a transformation in professional self-perception. This resonates with teacher AI competency frameworks, which emphasize the need to prepare teachers who can understand, apply, and critically evaluate these technologies. However, the findings allow this idea to be nuanced: developing AI competence does not only mean knowing how to use tools but also learning to make deliberate pedagogical decisions with them.

Regarding the difficulties faced during the creation process, the results show that the challenges were not exclusively technical. One central difficulty was prompt formulation. Some participants stated that the most complex part was providing appropriate instructions so that the tool would generate the expected application: "The most difficult thing was understanding how to give the prompt and how to make Gemini create the page" (U3-S5). This shows that interaction with AI requires a specific competence: translating a pedagogical intention into clear, contextualized, and actionable instructions. The findings also invite us to problematize the idea that AI "facilitates" the creation of resources. Although these tools reduce technical barriers, they do not eliminate the need for pedagogical knowledge. On the contrary, they can make the lack of didactic clarity more visible when instructions are vague or when the learning purpose is not sufficiently defined.

At this point, some responses require nuanced interpretation. A student's statement that "AI did all the work" should not necessarily be read as uncritical delegation, but rather as evidence of perceived efficiency: the pre-service teacher formulated a clear prompt, AI responded as requested, and the product matched the initial idea. From this perspective, agency does not disappear; rather, it shifts from technical execution to the pedagogical definition of the resource, the formulation of instructions, and the validation of the result. Nevertheless, an important tension exists: if creation with AI is reduced to requesting a product without critical review, there is a risk of superficial appropriation. It is necessary to distinguish between uncritical delegation and the intentional use of AI as support for educational design. The formative value lies in the pre-service teacher's ability to identify learning needs, formulate didactic proposals, guide AI through relevant instructions, and evaluate whether the product responds to the pedagogical purpose.

Technical and access-related difficulties must also be considered. Some participants pointed to limitations related to the functioning of the tool or access to certain functions. This aspect is relevant because it shows that the integration of generative AI into teacher education depends not only on individual motivation or competence, but also on material and institutional conditions. In Latin American contexts, this dimension is especially important, since access gaps can significantly affect the pedagogical appropriation of emerging technologies.

In terms of implications, the results suggest that ITE should incorporate guided experiences of creation with AI, but not as merely instrumental activities. Creating an application with AI can be an opportunity to develop competencies in didactic design, critical thinking, creativity, and pedagogical evaluation. To this end, it is necessary to teach pre-service teachers to identify learning needs, formulate objectives, construct contextualized prompts, review the quality of generated products, and reflect on the ethical and pedagogical limits of these tools.

Among the limitations of the study, it should be noted that the data are based on participants' self-reported perceptions; therefore, it is not possible to affirm that the applications created had a direct effect on English learning. Likewise, the positive evaluation of the experience does not guarantee that the products are pedagogically sound. It should also be considered that the experience was conditioned by the characteristics of the tool used and by possible restrictions in access or functionality. Finally, not all generated applications remained available through functional links, which may limit a complete analysis of the products created. Although diverse, the sample is small (N = 51) and limited to three Chilean universities, which restricts the transferability of the results. The asynchronous nature of the activity and the absence of direct observation by a teacher prevented the recording of difficulties in real time. In addition, a novelty bias is possible, since the experience was unprecedented for most participants.

Based on these results, future research could evaluate the pedagogical quality of the applications created by considering criteria such as alignment with learning objectives, appropriateness to linguistic level, relevance of feedback, accessibility, interactivity, and didactic coherence. It would also be relevant to implement these applications with real English learners in order to analyze their impact on motivation, autonomous practice, and learning. Likewise, different generative AI tools could be compared to identify differences in usability, teacher control, and the quality of generated products.

The main contribution of this study is not based solely on showing that pre-service teachers perceive their experience with generative AI positively, but on evidencing that the creation of educational applications with AI constitutes a complex formative practice that articulates creativity, pedagogical design, digital competence, ethical judgment, and disciplinary knowledge of English. Future research could evaluate the pedagogical quality of the applications created, implement them with real students, and compare different GenAI tools in terms of usability, teacher control, and didactic relevance in diverse Latin American contexts.

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ARTICLE / ARTÍCULO

Are students digitally literate? Progress, shortcomings and future challenges

¿Son los estudiantes competentes digitales? Avances, desajustes y retos de futuro

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Abstract: As part of the broader digitalisation of education and society, considerable efforts have been made in recent decades to develop the digital competencies of teachers and students, from primary education through to higher education. Based on a documentary review focused on the Ibero-American context, this article analyses the main advances, shortcomings, and challenges identified by educational research on students' digital competence over the last 25 years. Specifically, the article aims to examine the main advances and misalignments in relation to the established goals for the development of students' digital competencies. The methodology is based on the review of high-impact or highly relevant publications in academic databases, selected according to criteria of thematic relevance, citation count/relevance, open access, language, and geographical scope. The data are analysed inductively in response to the research questions. The findings reveal a predominant focus on the university context compared with school education, as well as an assessment approach that draws on European and international frameworks and relies largely on instruments based on self-perceived digital competence. Students have made progress in their digital competence; however, some areas still require specific training to ensure the exercise of citizenship with sufficient critical judgement in the consumption and dissemination of information, as well as to promote equity in education and personal well-being. The article concludes that the development of digital competence requires intentional, critical, and contextualised training models, together with further research addressing compulsory education, usage gaps, and the emerging challenges associated with artificial intelligence.

Keywords: Digital Competence; Educational Technology; Educational Research; Literature Review; Higher Education.

Resumen: Como parte del proceso de digitalización de la educación y de la sociedad, en las últimas décadas se ha hecho un esfuerzo encomiable para desarrollar las competencias digitales de docentes y estudiantes, desde la educación primaria hasta la universidad. Este artículo analiza, a partir de una revisión documental centrada en el ámbito iberoamericano, los principales avances, desajustes y retos identificados por la investigación educativa sobre la competencia digital del alumnado durante los últimos 25 años. El objetivo de este artículo es analizar los principales avances, así como los desajustes encontrados en relación a los objetivos establecidos sobre el desarrollo de las competencias digitales de los estudiantes. La metodología se basa en la revisión de publicaciones con alto impacto o relevancia en bases de datos académicas, seleccionadas mediante criterios de pertinencia temática, citación/relevancia, acceso abierto, idioma y delimitación geográfica. Los datos son analizados de forma inductiva, respondiendo a las preguntas de investigación. Los resultados ponen de manifiesto un foco mayoritario en el contexto universitario frente al ámbito escolar, una evaluación que toma como referencia marcos europeos e internacionales y pruebas de evaluación basadas en gran medida en la autopercepción de la competencia digital. Los estudiantes han avanzado en su competencia digital pero algunas áreas requieren todavía una formación específica para asegurar el ejercicio de una ciudadanía con suficiente criterio en el consumo y difusión de información, así como para asegurar la equidad en el ámbito educativo y el bienestar personal. Se concluye que el desarrollo de la competencia digital requiere modelos formativos intencionales, críticos y contextualizados, así como nuevas investigaciones que atiendan a la educación obligatoria, a las brechas de uso y a los retos emergentes asociados a la inteligencia artificial.

Palabras-clave: Competencia Digital, Tecnología Educativa, Investigación Educativa, Revisión Documental, Educación Superior.

1. Introduction

The progress of contemporary society has been characterised by an unprecedented pace of technological change that has radically transformed the structures of communication, production, and learning. Over the past 25 years, the transition from industrial society to the information society, and subsequently to the network society (Castells, 2005), has posed fundamental challenges to educational systems (García-Valcárcel, 2016). Education can no longer be confined to the transmission of static knowledge; rather, it must focus on preparing citizens who are capable of navigating a complex digital ecosystem in which information is abundant but often fragmented or unreliable.

The progression of the concept of digital competence highlights a shift in perspective from an instrumental view of digital literacy towards a cognitive and critical competence. International organisations such as the OECD (2001), through the DeSeCo project, redefined competences not merely as technical skills but as the capacity to mobilise cognitive resources in response to complex social demands. This conceptual shift implies that digital competence cannot be reduced to the instrumental use of devices or applications. Rather, digital competence is understood as a multifaceted capability that integrates knowledge, skills, attitudes, critical judgement, ethical responsibility, and civic participation within technology-mediated environments.

In the European context, the European Qualifications Framework for Lifelong Learning (European Union, 2009) consolidated digital competence as one of the eight key competences for lifelong learning, encompassing the safe and critical use of information and communication technologies (ICT) for work, leisure, and communication. In 2013, the European Digital Competence Framework (DigComp) was published (Ferrari, 2013), and its influence on the development of training programmes and assessment processes relating to digital competence has been unquestionable. In Ibero-America, meanwhile, this progression has been closely linked to the need to overcome the digital access divide; however, the focus has gradually shifted towards media literacy and digital citizenship (UNESCO, 2011).

Over the past 25 years, significant investment efforts have been made across Ibero-America. Initiatives such as Escuela 2.0 in Spain and Plan Ceibal in Uruguay represented ambitious attempts to implement the one-to-one (1:1) model, whereby each student is provided with a personal computer, in compulsory education. These initiatives, together with subsequent programmes aimed at promoting digital access in schools, have resulted in most educational institutions now having connectivity and digital devices available in classrooms. However, concerns have been raised regarding the effectiveness, quality, and long-term maintenance of these resources (Area, 2011; UNESCO, 2023).

Concerning students' cognitive capacities, one of the most persistent findings in the literature has been the challenge to the myth of the digital native. Research has shown that, although young people often demonstrate a high degree of proficiency in the use of mobile devices and social media for leisure purposes, they lack the critical competences required for academic information searches, the evaluation of information sources, and the creation of complex digital content. Studies have also highlighted that students tend to overestimate their own digital capabilities, leading to

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a discrepancy between their self-perceptions and their actual levels of performance (Juca-Maldonado et al., 2025).

There is ample evidence that the everyday use of technology does not, in itself, lead to the development of digital competence. Consequently, education and training in this area are essential to promote a more conscious, critical, and purposeful use of technology. Such training is particularly effective when introduced at an early age (Fundación Cibervoluntarios, 2026). According to this report, the most significant improvements are observed in areas such as privacy, online safety, and risk management, whereas the impact on more socially oriented competences is comparatively limited. The findings further indicate that young people who combine physical and digital environments exhibit the most favourable emotional well-being indicators. These results reinforce the notion that the crucial factor lies in how technology is integrated into everyday life. Accordingly, the appropriation of technology should not be understood merely in terms of access or use, but rather as a complex process involving the interplay of experiences, knowledge, and attitudes, and one that requires educational guidance and support. In any case, the appropriation of technology constitutes the foundation for the development of Citizen Digital Sovereignty, a concept whose guiding principles include the right of all individuals to free digital education that enables them to use technology responsibly and critically, as well as the right of citizens to participate actively in decisions regarding the design, governance, and use of technology.

In this context, it is imperative to strengthen students' critical thinking skills and to ensure access to digital technologies to address the divides that have been amplified by the network society. Education must assume responsibility for preparing citizens who not only use technology but also understand it and appropriate it in ways that are informed by ethical and social considerations. Particular attention should be paid to the needs of the most vulnerable groups.

On the other hand, pedagogical resistance remains prevalent in many educational contexts. Technology has often been incorporated merely to replicate traditional practices in a digital format, without bringing about any substantial transformation in teaching methodologies. As highlighted in the UNESCO report (2023), educational technology should be learner-centred and grounded in evidence rather than driven by technological enthusiasm alone.

At present, artificial intelligence (AI) is emerging as the most disruptive technology. Its potential to personalise learning through intelligent tutoring systems, provide educational resources that support learner diversity, and facilitate self-assessment and continuous formative assessment processes that empower students in their autonomous learning is undeniable. However, these opportunities are accompanied by new ethical challenges, including data privacy, algorithmic bias, and the potential dehumanisation of the educational process (European Commission, 2022). European guidelines emphasise that the use of AI should be trustworthy and subject to human oversight, requiring educators to develop new digital competences related to understanding AI, data governance, the implications of AI for equity and human agency, the identification of algorithmic bias, and awareness of the limitations of AI in the assessment of student learning.

This article analyses the trajectory of students' digital competence development, focusing on Spain and Ibero-America. It examines both the progress achieved and the shortcomings that educational research has brought to light.

2. Methodology

The present study is based on an exploratory and analytical documentary review aimed at identifying trends, advances, and shortcomings in Ibero-American research on students' digital competence. The review of the scientific literature seeks to examine the evidence generated by previous studies while identifying knowledge gaps and future challenges in this field. The selection of documents was guided by criteria including thematic relevance, geographical scope, open-access availability, language, and position within academic databases according to citation impact or relevance. In this regard, citation counts are employed as an approximate indicator of scientific impact rather than as an exclusive measure of quality or current relevance. The aim, therefore, is to provide a synthesis of the most relevant research available in the Ibero-American context concerning the development of students' digital competence, with a particular focus on the advances achieved and the challenges that remain.

The research strategy focused on the retrieval of documentary sources, specifically journal articles, from the principal databases used in educational research. Searches were conducted in two languages, English and Spanish, across the following databases: Web of Science (WoS), Scopus, Dialnet, InDICEs-CSIC, and Google Scholar.

Given the objectives of the study, the search was restricted to the Ibero-American context. According to the Ibero-American General Secretariat (SEGIB), Ibero-America comprises 19 countries in the Americas and three European countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela, Andorra, Spain, and Portugal. Consequently, the literature search was limited to research conducted in these countries.

The following search string was employed: (Competencia digital OR Digital competence OR digital skills OR alfabetización digital OR digital literacy OR alfabetización informacional OR information literacy) AND (estudiantes OR alumnos OR students OR pupils). The search was restricted to articles in which these keywords appeared in the title. The time frame covered the period from 2000 to the present to capture relevant research developments over time (Table 1).

Table 1. Inclusion criteria and search strategies.

Category	Criteria
Databases	WOS, SCOPUS, DIALNET, InDICEs-CSIC, and Google Scholar
Scope	Ibero-American
Time period	2000-2026
Type of documents	Open-access articles
Language	English and Spanish
Search string	(Competencia digital OR Digital competence OR digital skills OR alfabetización digital OR digital literacy OR alfabetización informacional OR informational literacy) AND (Estudiantes OR alumnos OR students OR pupils)
Search field	Article title
Sorting results	Number of citations/Relevance

Once the search had been conducted in each database, the results were screened using a single inclusion criterion: the study had to address students' digital competence. Consequently, documents that did not focus on the student population were excluded. The remaining records were then ranked according to citation counts in order to identify the most relevant publications, as the number of citations may serve as an objective indicator of scientific relevance or impact. In the case of Dialnet and InDICEs-CSIC, where citation data are not provided, records were ranked according to the relevance criteria established by each database. Subsequently, the first 20 references from each database were selected for analysis. The findings should therefore be interpreted as a synthesis of publications with high impact or accumulated relevance, rather than as an exhaustive review of all the scientific literature available. The results relating to the number of references selected from each database are presented in Table 2.

Table 2. Results from the database search.

Databases	Number of references	Selected references
Google Scholar	162	20
WOS	140	20
SCOPUS	20	20
DIALNET	22	20
InDICEs-CSIC	102	20
Total (excluding duplicates)		76

The selected references were compiled in a spreadsheet containing the essential publication data, including citation counts from each database, article title, authors, year of publication, journal, study focus, target population, country, APA reference, and abstract. The records were ranked according to the number of citations received, and duplicate references were removed, resulting in a final corpus of 76 documents. This dataset is available as an appendix to the present manuscript (Supplementary Material 1), reflecting a commitment to the principles of Open Science. Following the selection process, the references were reviewed once again to determine whether they were indexed in additional databases, and this information was also recorded in the supplementary material.

Once the documents had been selected, the references were analysed in two phases.

Phase 1. Based on the 76 selected references, an initial analysis was undertaken to address the following research questions:

1) In which countries were the studies conducted?
2) Are there any researchers who stand out within this specific field of research?
3) Which student populations have been the primary focus of the research?
4) Which research methodologies have been most frequently employed?
5) What are the main variables studied?
6) What are the main conclusions of the studies?

Phase 2. To undertake a more in-depth examination of the most influential publications, the 15 studies with the highest citation counts or levels of relevance were analysed. This second stage of the analysis sought to address the following research questions:

1) What reference frameworks have been used to assess students' digital competence?
2) Has the focus of research on digital competence evolved over time?
3) What have been the principal advances in research on students' digital competence?
4) What challenges have researchers identified regarding the development of students' digital competence?
5) What areas of future research do the authors suggest in relation to this topic?

For the data analysis, NotebookLM was used to generate an initial response to the research questions. This preliminary output served as a draft that the researchers subsequently analysed. The prompts employed were as follows:

> Prompt Phase 1: With the aim of analysing the main advances, as well as the gaps and shortcomings identified in relation to the established objectives for the development of students' digital competence, and taking into account the information contained in the attached database, analyse its content to answer the following questions: (research questions listed).
>
> Prompt Phase 2: With the aim of analysing the main advances, as well as the gaps and shortcomings identified in relation to the established objectives for the development of students' digital competence, and taking into account the 15 attached documentary sources, analyse their content to answer the following questions: (research questions listed).

The analysis conducted by the researchers involved a critical review of the draft generated by NotebookLM. This process included verifying that the information presented was the most relevant to the research questions, accurately reflected the findings reported in the original studies, and was free from potential biases. In addition, supplementary information considered pertinent to addressing the research questions was included.

3. Results

The results are presented according to the two phases of analysis that structured the study.

3.1. Phase 1. Analysis of all the selected documentary sources.

In which countries were the studies conducted?

Spain is the country with the highest level of scientific output on students' digital competence (Gutiérrez & Tyner, 2012; Gisbert & Esteve, 2011; Area & Guarro, 2012). In Latin America, notable contributions have been made in Mexico (García-Ávila, 2017; Islas & Franco, 2018), Chile (Jara et al., 2015; Cabero-Almenara et al., 2023), Colombia (Arrieta & Montes, 2011; López-Gil & Sevillano, 2020), Venezuela (Esteve & Gisbert, 2013; Godoy, 2009), Cuba (George & Avello-Martínez, 2021; Hernández-Campillo, Veranes, & Arias, 2023), Peru (Rumiche & Chunga, 2019), and Ecuador (Henríquez-Coronel et al., 2018; Jaén & Mena, 2021). A geographical overview of the publications analysed is presented in Figure 1.

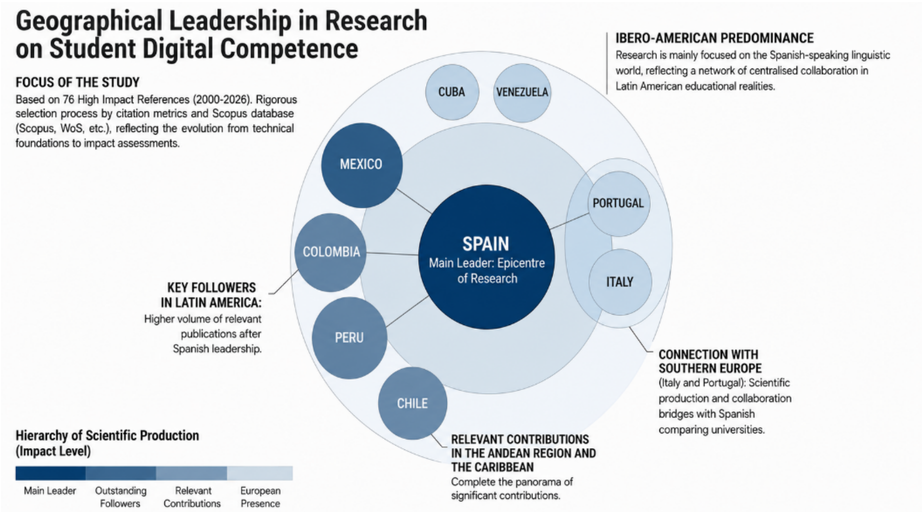

Figure 1. Geographical distribution of leading research on students' digital competence. Source: Authors' own elaboration based on data systematised by the research team, with support from generative artificial intelligence tools. All data presented were subsequently reviewed and manually verified by the authors.

Are there any researchers who stand out within this specific field of research?

Several authors have established a sustained and influential research trajectory in the field of students' digital competence. The most prominent contributors identified in the literature include the following (Figure 2):

- Mercedes Gisbert Cervera, a leading scholar in competency assessment profile benchmarks (Gisbert & Esteve, 2011; Gisbert et al., 2016; Sánchez-Caballé et al., 2020).

– Julio Cabero Almenara. Specialist in digital literacy and its relationship with academic achievement (Cabero-Almenara & Llorente-Cejudo, 2008; Cabero-Almenara et al., 2009; Cabero-Almenara et al., 2023).

– Francesc Esteve Mon. Researcher whose work has centred on assessing digital competence and computational thinking (Esteve & Gisbert, 2013; Esteve-Mon et al., 2020).

– Manuel Area Moreira. Researcher who has made significant contributions to the theoretical foundations of citizen digital literacy (Area & Guarro, 2012; Area-Moreira, 2014).

– Ignacio Aguaded. Recognised for his influential work in the field of media literacy (Bonilla-del-Río & Aguaded, 2018; Pérez-Escoda et al., 2019).

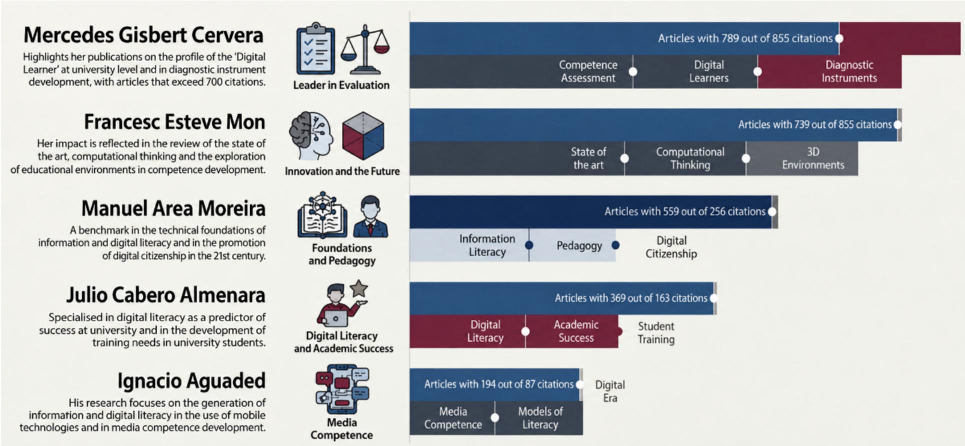

Figure 2. Leading researchers in the field of students' digital competence. Source: Authors' own elaboration based on data systematised by the research team, with support from generative artificial intelligence tools. All data presented were subsequently reviewed and manually verified by the authors.

Which student populations have been the primary focus of the research?

The majority of the studies reviewed are situated within the context of higher education. A notable emphasis is placed on students' training to become future teachers (Cabezas et al., 2014; Esteve-Mon et al., 2020; Moreno et al., 2018). By contrast, only 8% of the studies analysed focus on compulsory education, including both primary education (Bonilla-del-Río & Aguaded, 2018; Fernández et al., 2017; García-Ruiz et al., 2014) and secondary education (Jara et al., 2015; Tarango, 2014; Valverde-Crespo et al., 2018). Studies addressing other specific populations, such as adult learners (Padilla-Carmona et al., 2016) or students with disabilities, are comparatively scarce (Millán, 2011).

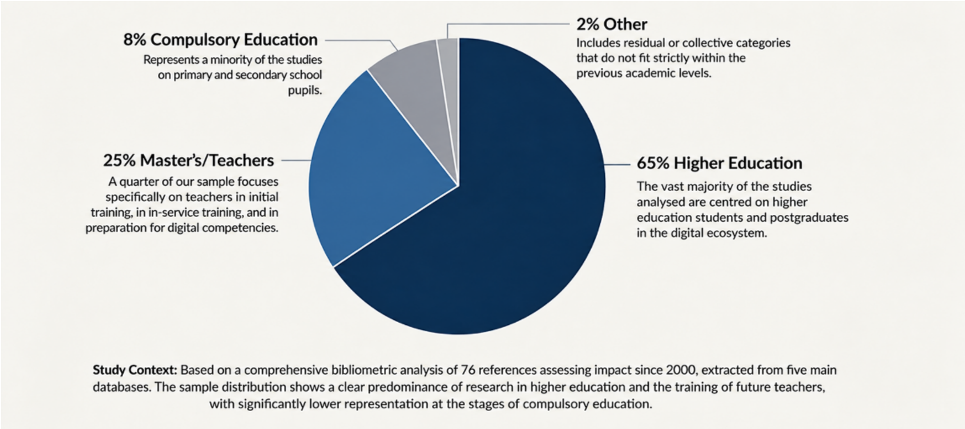

Figure 3. Student populations represented in digital competence research. Authors' own elaboration based on data systematised by the research team, with support from generative artificial intelligence tools. All data presented were subsequently reviewed and manually verified by the authors.

Which research methodologies have been most frequently employed?

Quantitative methodologies are the most frequently employed in the studies reviewed, with a predominance of survey-based approaches that rely on students' self-perceptions of their own digital competence (Centeno & Cubo, 2013; López-Meneses et al., 2020; Silva-Quiroz & Morales-Morgado, 2022). Systematic literature reviews also represent a significant proportion of the research (George Reyes & Avello-Martínez, 2021; Reis et al., 2019; Sánchez-Caballé et al., 2020), as do mixed-methods approaches that combine questionnaires with focus groups or case studies (Jara et al., 2015; López-Gil & Sevillano, 2020). To a lesser extent, quasi-experimental designs have also been employed (Fernández et al., 2017).

What are the main variables studied?

Most studies focus on the dimensions established by the DigComp Framework, including information literacy, communication, digital content creation, safety, and problem-solving (López-Meneses et al., 2020; Moreno et al., 2018). A considerable proportion of the research also examines sociodemographic factors, particularly gender and age (Esteve-Mon et al., 2020; Zhao et al., 2021), as well as socio-economic factors, such as household income, parental educational attainment, and access to technology in the home environment (Cabero-Almenara et al., 2009; Jara et al., 2015; Silva-Quiroz & Morales-Morgado, 2022). Academic performance is another frequently investigated variable, with several studies exploring the relationship between digital skills and educational achievement (Cabero-Almenara et al., 2023; Guzmán et al., 2017; Islas & Franco, 2018). Finally, some studies address attitudinal variables, including students' disposition and their levels of self-confidence towards the use of ICT (Cabellos et al., 2024; Centeno & Cubo, 2013).

What are the main conclusions in the studies?

The specialised literature has consistently challenged the widely held assumption that generations born and raised in highly digitalised environments inherently possess high levels of digital competence. This proposition, commonly referred to as the digital native myth, has been progressively undermined by research demonstrating that everyday familiarity with digital technologies does not automatically translate into competent, reflective, or academically meaningful uses of technology. In this respect, numerous studies have shown that, although students usually develop skills associated with entertainment, communication, and the consumption of digital content, they frequently encounter significant difficulties when required to mobilise more complex competences related to the search, selection, critical evaluation, and management of information (de Vicente et al., 2022; García-Ruiz & Aguaded, 2014; Gisbert & Esteve, 2011).

On the other hand, various studies have highlighted a gap between digital learning developed in informal contexts and the demands associated with formal educational environments. Although students acquire numerous digital practices autonomously through their everyday experiences, these forms of learning do not tend to transfer either spontaneously or effectively to academic tasks requiring analysis, evidence evaluation, knowledge production, or the resolution of complex problems. This disconnect suggests that the frequent use of technology does not, in itself, guarantee the development of competences applicable to university learning or professional contexts (Guzmán et al., 2017; López-Gil & Sevillano, 2020).

Likewise, empirical evidence indicates that certain dimensions of digital competence continue to represent particular areas of vulnerability among students. These include digital safety, multimedia content creation, and, most notably, the critical evaluation of information and digital sources. Such dimensions require higher-order cognitive processes, including verification, interpretation, synthesis, and critical judgement, which typically exhibit lower levels of performance than more instrumental forms of digital competence (Moreno et al., 2018; Sales et al., 2020; Silva-Quiroz & Morales-Morgado, 2022). This situation becomes even more significant within the contemporary digital ecosystem, characterised by information overload, content automation, and the increasing integration of artificial intelligence systems, all of which demand new forms of literacy.

Finally, numerous studies highlight that family context and socio-economic conditions continue to exert a significant influence on the development of digital competence. Despite the growing availability of technological resources and institutional efforts to reduce inequalities in access, the home environment remains a determining factor in shaping opportunities for digital learning and the extent to which these opportunities translate into educational benefits. Variables such as the availability of resources, educational support within the family, and opportunities for technology use beyond the school setting account for substantial differences in levels of digital competence attained by students (Fernández-Mellizo & Manzano, 2018; Jara et al., 2015). In this regard, the contemporary digital divide can no longer be understood solely in terms of access to devices; increasingly, it manifests itself as a divide in patterns of use, educational benefit, and the development of more sophisticated digital competences. These findings reinforce the need to promote educational models that support the intentional, critical, and equitable development of students' digital competence.

3.2. Phase 2. An in-depth analysis of the most significant publications in the field of study.

What reference frameworks have been used to assess students' digital competence?

The literature reveals a clear progression from instrumental models, focused primarily on the use of tools and the performance of tasks through technological applications, towards more complex and holistic models encompassing cognitive processes, attitudes, and a broad range of skills. In particular, the following reference frameworks can be identified:

- DigComp 2.1 (European Digital Competence Framework): This is the predominant framework in contemporary research on digital competence. It conceptualises digital competence through five competence areas (information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving), which are further subdivided into 21 specific competences (Carretero et al., 2017; López-Meneses et al., 2020).

- National Educational Technology Standards for Students (NETS-S): Developed by the International Society for Technology in Education (ISTE, 2008), this framework places particular emphasis on the development of creativity, innovation, and responsible digital citizenship (Esteve & Gisbert, 2013).

- UNESCO Framework (2008): Proposed by UNESCO, this framework adopts a hierarchical progression model in which learning advances sequentially from the acquisition of basic ICT knowledge and skills to stages of knowledge deepening and, ultimately, knowledge creation (Gutiérrez & Tyner, 2012).

- Larraz's Rubric (2012): Widely recognised within the Spanish context, this framework operationalises digital competence through four complementary literacies: information literacy, technological literacy, multimedia literacy, and communicative literacy (Esteve & Gisbert, 2013; Gisbert et al., 2016).

To support the application of these frameworks, researchers have validated a range of diagnostic instruments. Among the most widely used is the ICT Competences Inventory (INCOTIC), developed to assess students' self-perceived digital competence upon entry to higher education (Gisbert et al., 2011). Another prominent instrument is the University Students' Basic Digital Competences 2.0 (COBADI) questionnaire, designed specifically to measure digital competences associated with the use of Web 2.0 tools and technologies (López-Meneses et al., 2020).

Has the focus of research on digital competence evolved over time?

The documentary analysis reveals a clear evolution in the research perspective adopted towards students' digital competence. Specifically, the field has undergone a transition from a predominantly instrumental perspective, concerned primarily with the technical aspects of using hardware and software, towards a socio-cognitive approach that conceptualises digital competence as a complex form of knowing how to act, encompassing critical thinking and ethical judgement (Area-Moreira, 2014; Gutiérrez & Tyner, 2012).

Furthermore, research has increasingly demonstrated that the technological proficiency displayed by younger generations is largely recreational in nature and often superficial, revealing significant shortcomings in competences that are specifically academic in character (Gisbert & Esteve, 2011; Guzmán et al., 2017; Sánchez-Caballé et al., 2020). Consequently, more recent studies have shifted their focus towards the analysis of formal educational contexts and digital well-being.

Finally, research has increasingly challenged the notion of literacy as a unidimensional construct. The theoretical corpus has progressively converged around the concept of multiliteracies, understood as the synergistic integration of media, information, and digital literacies (Area-Moreira & Guarro, 2012).

What have been the principal advances in research on students' digital competence?

The main advances identified in the literature relate to two main dimensions: assessment methodology and the conceptual clarification of digital competence.

With regard to the methodological dimension, significant progress has been made in developing instruments that can measure levels of digital competence acquisition more objectively and systematically. In this respect, the evidence points to a transition from assessment models based on self-perception towards approaches focused on actual performance. In some cases, such assessment is implemented using three-dimensional simulation environments and virtual laboratories, tools that enable researchers to examine students' ability to solve authentic challenges in real time (Esteve y Gisbert, 2013; Gisbert et al., 2016).

At the conceptual level, distinctions have been drawn between the different dimensions of digital competence associated with students' knowledge, skills, and attitudes, which are not always aligned. The findings indicate that, despite considerable heterogeneity in levels of technical and cognitive proficiency shown by students, a highly positive disposition towards digital technologies predominates, with such technologies perceived as essential tools for both learning and everyday life (Centeno & Cubo, 2013).

What challenges have researchers identified regarding the development of students' digital competence?

The findings identify four fundamental challenges that shape the development of students' digital competence.

Firstly, there is an asymmetry between students' everyday digital skills and their academic digital competences. Whilst students demonstrate advanced levels of proficiency in environments associated with social interaction and leisure consumption, they exhibit significant deficiencies in the academic management of information, particularly concerning database searching, the critical evaluation of sources, and the production of original content. Secondly, there is a lack of diversified educational methodologies—hybrid, multimodal, and collaborative in nature (Guzmán et al., 2017)—that would enable students to develop these competences through experience and reflective practice. Thirdly, gender bias persists in the self-perception of digital competence. Significant differences have been observed in favour of male students, both in terms of perceived technical proficiency and the frequency with which more complex technological tools are used (Centeno & Cubo, 2013). Finally, teacher digital literacy emerges as a critical factor. The training and professional development of teachers constitute an indispensable pillar, given that the effective development of students' digital competence is directly contingent upon the prior level of qualification and digital competence of their teachers (Gisbert et al., 2016).

What areas of future research do the authors suggest in relation to this topic?

The articles reviewed suggest several proposals aimed at consolidation and innovation, structured around four main strands. Firstly, a line of research has been identified that focuses on the design of strategies for the formal certification of students' digital competence, as well as on the development and validation of training models capable of guaranteeing these competence levels through longitudinal methodologies (Cabero & Llorente, 2008). Secondly, computational thinking has emerged as a key component of students' digital competence (Esteve-Mon et al., 2020). In addition, growing interest has been observed in learning analytics and the personalisation of teaching, with an emphasis on developing intelligent and adaptive tools capable of tailoring learning content to students' multiple intelligences (López-Meneses et al., 2020). Finally, the authors highlight the need for further research into the potential of 3D simulations as a means of obtaining authentic evidence of competence-based performance (Gisbert et al., 2016).

4. Discussion and Conclusions

The analysis of the most influential articles on students' digital competence confirms the presence of an intense interest within the Ibero-American scientific community to understand the extent to which the student population is developing this essential competence for active citizenship, in line with the recommendations put forward by international organisations (Comisión Europea, 2022; UNESCO, 2023).

As has been highlighted, research has focused primarily on the higher education sector, resulting in limited attention being paid to school-based contexts. Nevertheless, understanding the situation of non-university students is of considerable importance, given the need to foster responsible and active digital citizenship. Consequently, this represents a significant gap in the literature, as such knowledge should underpin evidence-based decision-making in public policy.

Concerning the assessment of students' levels of digital competence, the widespread use of self-perception questionnaires presents clear limitations, including subjectivity and social desirability bias (Paulhus, 2002). Consequently, further progress is required in the development of more objective assessment instruments.

The findings of the studies reviewed indicate that, although technological resources have become available in the majority of households and educational settings, this has not necessarily led to higher levels of information literacy. On the contrary, the evidence suggests that increased use of these technologies may be associated with a deterioration in cognitive processes such as attention, concentration, critical thinking, and creativity (Herrero-Curiel & La-Rosa, 2022). Therefore, without adequate training in the responsible use of digital technologies, their effects may be detrimental. A lack of such training can render students particularly vulnerable to misinformation and manipulation, potentially giving rise to situations of stress and anxiety.

Furthermore, the training and assessment processes developed across the Ibero-American context have generally aligned with the European DigComp framework. Although this framework has been periodically updated to incorporate emerging technologies such as artificial intelligence, it has provided a stable reference model for the transferability of research findings from studies carried out in various countries within this geographical area. The framework has identified several imbalances in the development of digital competence (Basilotta et al., 2020), thereby facilitating the design of specific action plans in diverse educational contexts and guiding teacher training and certification pathways through the use of self-assessment and autonomous learning strategies.

An interesting progression can also be observed over time in the research questions being posed, moving from a focus largely centred on the instrumental use of technology towards enquiries concerned with cognitive processes, attitudes, and digital well-being. This shift has coincided with the emergence of communication, learning, and mental health issues associated with the inappropriate use of digital technologies, including cyberbullying, addiction, excessive content consumption, overstimulation, reduced concentration, and superficial learning, among others. Consequently, scholarly interest has gradually moved from examining technological practices themselves to investigating their consequences for students' lives. The findings suggest that the field has evolved from approaches primarily concerned with access to technology and its instrumental use towards more demanding models of critical, media, and information literacy.

Advances in this field of research can be seen in the availability of a comprehensive and well-developed conceptual framework, around which a considerable degree of international consensus has been established. In addition, a range of valuable instruments for assessing digital competence have been developed and validated for different educational contexts, including compulsory education and higher education. These instruments are based on clearly defined indicators and are aligned with the competences set out in the reference framework (García-Valcárcel et al., 2020). Assessment processes have also incorporated emerging technologies, such as virtual simulations, which enable more objective forms of evaluation situated within authentic real-world contexts.

With regard to future challenges, particular emphasis should be placed on the need for participatory research in which teachers from different educational levels work collaboratively to analyse the objectives to be achieved at each stage of education and to agree upon pedagogical methodologies and collaborative processes involving families in the education of children and young people. Research must also continue to explore the dissonances between students' interest in technology in their everyday lives and its use within academic contexts. In particular, further investigation is needed into how digital competence education can be designed in ways that are meaningful across all the environments that shape students' lived experiences.

Furthermore, it is impossible to overlook the challenge that artificial intelligence poses for digital literacy. As a technology that fundamentally reconfigures the dialogical relationship between humans and machines, AI has the potential both to enhance and to undermine the thinking skills that are essential for learning. Current research is examining the transformations brought about by this powerful tool in student learning. It is the responsibility of researchers in the field of education to gather evidence regarding these changes and to propose new learning methodologies that harness the potential of AI whilst mitigating adverse effects, such as cognitive debt (Watts, 2025) and the underdevelopment of students' intellectual capacities. Nevertheless, given that the majority of the studies included in the corpus reviewed were conducted prior to the widespread adoption of generative AI, any claims regarding its effects should be understood as prospective considerations rather than as empirical conclusions directly derived from the studies analysed.

Finally, digital divides related to gender, socioeconomic background, age, and other factors must continue to be investigated in order to inform the implementation of more inclusive policies, ensuring that all individuals can participate in society without barriers and exercise their rights as fully empowered citizens.

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ARTICLE / ARTÍCULO

Hybrid Methods and E-Methods in Educational Research: An Analysis of Master's and Doctoral Theses

Métodos híbridos y e-métodos en investigación educativa: análisis de tesis de maestría y doctorado

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Abstract: People increasingly move across online and offline contexts, and these flows shape their educational practices, interactions, and forms of participation. This complexity calls for flexible, creative, and situated methodological approaches capable of documenting social and educational phenomena that unfold across physical and digital environments. This study explores the characteristics of hybrid methodological designs that combine traditional research methods with e-methods. To this end, a textual analysis was conducted of nineteen master's and doctoral theses from the Institute of Education Sciences at the Autonomous University of the State of Morelos, Mexico. Methodological sections and research design-related findings were extracted from each document, organized in a hermeneutic unit, and analyzed through coding and categorization. The analysis identified three types of research scenarios in hybrid methodological designs: natural scenarios, where online spaces and practices existed before the research process; generated scenarios, where digital spaces or activities were created or guided by the researcher; and dual scenarios, where both logics converged. These findings also reveal recurring challenges related to access to participants, privacy, ethical safeguards, digital competencies, researcher control over online settings, identity verification, and multimodal data. The study provides a useful typology to guide methodological decision-making in educational research that integrates both face-to-face and digital practices.

Keywords: Hybrid Methods, E-Methods, Educational Research, Research Design, Virtual Environments, Educational Technology.

Resumen: Las prácticas educativas contemporáneas se desarrollan en continuidad entre contextos presenciales y digitales, lo que exige diseños metodológicos capaces de registrar fenómenos que no pueden comprenderse únicamente desde lo presencial ni desde lo virtual. Este artículo analiza las características de los diseños metodológicos híbridos que combinan métodos tradicionales y e-métodos en investigación educativa. Para ello, se realizó un análisis textual de 19 tesis de maestría y doctorado del Instituto de Ciencias de la Educación de la Universidad Autónoma del Estado de Morelos, en México, seleccionadas por incorporar estrategias de recogida de datos en línea y fuera de línea. Se extrajeron los fragmentos relativos al diseño metodológico y a los procedimientos de obtención de información, se organizaron en una unidad hermenéutica y se analizaron mediante codificación y categorización. Los resultados permiten distinguir tres tipos de escenarios en los diseños metodológicos híbridos: naturales, cuando los espacios y prácticas digitales existen antes de la investigación; generados, cuando son creados o guiados por quien investiga; y duales, cuando convergen ambas lógicas. Asimismo, se identifican desafíos vinculados al acceso a participantes, la privacidad, el consentimiento, las competencias digitales, el control del escenario, la verificación de identidad y el análisis de datos multimodales. El estudio aporta una tipología útil para orientar decisiones metodológicas en investigaciones educativas que integran prácticas presenciales y digitales.

Palabras-clave: Métodos Híbridos, E-Métodos, Investigación Educativa, Diseños de Investigación, Ambientes Virtuales, Tecnología Educativa.

1. Introduction

Up until recently, the methodological designs within Social Sciences used to be classified in one of the following three approaches: quantitative, qualitative or mixed, the last one being the combination of the previous two. Since the emergence of the so-called e-methods, an additional option is available, which interacts with the previous ones: the hybrid design. The 'hybrid' adjective is applied to refer to a design which combines offline and online data collection techniques—that is, traditional methods and e-methods.

It's important to point out that the offline and online distinction doesn't intend to draw a line between these methods, but to point out their necessary convergence through hybrid designs, taking into account that today many human beings move fluidly between these two realities, making it more complex for researchers to address these domains as separate entities

Thus, the methods and the e-methods are combined into hybrid designs when we address phenomena which flows between offline and online contexts. An important distinction is that the use of e-methods applies within research projects in which internet is our field and/or medium of study (Castillo and Zorrilla, 2021).

This study distinguishes between the methodological approach of a research project and the contextual or technical conditions under which the data are collected. The quantitative, qualitative and mixed approaches relate to the logic of evidence generation, analysis, and integration. In contrast, the concept of a hybrid design refers to the combination of contexts, techniques, or methods for collecting data—both online and offline. Therefore, a hybrid study can be qualitative, quantitative, or mixed, depending on the nature of its research questions, data, and analytical procedures.

The present complexity of the research designs in areas such as communication and education requires the combination of e-methods and traditional methods, meaning, hybrid designs, a relatively new approach which implies multiple challenges for the researchers and occasionally for the participants as well.

Among the pioneers in the use of e-methods is Howard Rheingold (1993), who drew on his experience as a user to study virtual communities. Another pioneer is Sherry Turkle (1995), who studied 'life on the screen' and how through technological mediation people transformed their identities, their relationships, their ways of doing politics and even getting emotionally involved.

Three decades after these early forays into the online social world, e-methods have become an established component of the researcher's methodological toolkit, and several authoritative handbooks documents and discuss their use, notably those by Fielding, Lee & Blank (2008 and 2017), the one by Consalvo & Ess (2011), the one by Lupton (2015), and the one by Minocha & Petre (2012). Hine's (2000, 2004, and 2008) proposals on virtual ethnography are also frequently cited.

There are numerous studies on e-methodologies and Internet research, including Archibald et al. (2019) on the use of Zoom for qualitative data collection; Ardèvol, Estalella & Domínguez (2008) on Internet ethnographies; Frączkowska (2020) and Latkovikj & Popovska (2019), who examine the advantages and disadvantages of online research; Holt (2020) evaluates traditional and non-traditional methods for studying online phenomena; Quintana-Pujalte & Ramos-Serrano (2023) report on an Ibero-American study of digital ethnography; and Wright (2023) examines various online research methods, as well as related challenges and best practices that have been reported by various authors across a range of disciplines.

Since the methodological approach explored in this article is hybrid in nature, we chose to revisit and adapt Bruhn Jensen's (2011, p. 48) classification of the most commonly used methods in Internet studies, which are detailed in Table 1. This table summarizes a classification of methods used in Internet studies, allowing us to observe how some traditional procedures find equivalents in digital formats, while other e-methods emerge specifically in online environments.

Table 1. Basic methods used in Internet studies.

	Quantitative	**Qualitative**
Discourse/language/writing	Survey and e-survey	Interview and e-interview Focal group and e-focal group
Behavior/action	Experiment (online)	Observation and e-observation (participant and non-participant)
Texts/documents/artifacts	Content analysis (online)	Discourse analysis; textual and multimedia analysis; diary and digital journal

Source: Adapted by the authors from Bruhn Jensen (2011, p. 48)

This classification provides the basis for the analysis of the reviewed theses, not for the purpose of cataloging techniques in isolation, but rather to identify how they come together in specific hybrid designs.

As can be seen, some of the so-called e-methods are online digital adaptations of tools which are used offline, such as surveys, interviews, or observations. Their digitization and transition to an online format often provide added value, such as the incorporation of automated features, but it can also mean that the researcher has less control over the context in which they are applied.

It's important to clarify that not all e-methods are adaptations of the traditional ones. They can be devices created specifically to explore an online phenomenon, such as an online multiplatform diary or a group within a digital social media which responds to specific dynamics designed by whoever is in charge of the research project. According to Mujica-Sequera (2022) the e-methods can include experimentation, a research panel, analytical processing and focal groups, all of them online.

Although the e-methods most frequently mentioned in the literature are e-observation, e-interviews, and e-surveys, the use of Web 2.0 applications has made it increasingly common to systematically collect user information from various services—such as digital social media and virtual learning environments—which provide access to large volumes of data, better known as big data. Peng et al. (2012) refer to this as “web content mining” and “user traffic logs,” the collection and analysis of which are becoming increasingly streamlined thanks to artificial intelligence tools (Lopezosa & Codina, 2023; Mellon, Bailey, Scott, Breckwoldt, Miori & Schmedeman, 2023).

Although literature centered on online research, digital ethnography and e-methods has increased significantly, the studies which analyze how these resources are integrated with traditional methods in specific educational research projects are still in short supply. In particular, it is necessary to understand what types of methodological scenarios arise when research combines face-to-face and digital settings, what role e-methods play within the design, and what challenges their implementation poses. From this perspective, the objective of this study is to analyze the characteristics of hybrid methodological designs found in master's and doctoral theses at ICE-UAEM, identify common and divergent patterns, and propose a typology of scenarios that can guide future educational research.

2. Methodology

This study is conceived as a qualitative literature review of a "meta-methodological" nature. Its purpose was to examine how the research designs of the reviewed theses were structured when they combined traditional methods and e-methods. The corpus consisted of 19 master's and doctoral theses. It stems from the direct guidance provided by the authors and other researchers to students in the Master's Program in Educational Research and the PhD in Education at the Institute of Educational Sciences (ICE) of the Autonomous University of the State of Morelos (UAEM) in Mexico. It also derives from the authors' own research work. To reduce potential familiarity bias, the classification of the theses was based on documentary evidence found in the final texts and not on external information not recorded in the theses.

For this study, a review was conducted of 19 theses by ICE graduates—eleven doctoral theses and eight master's theses—developed using hybrid designs. The method employed was a textual review of the completed theses. All UAEM theses are open access, as both educational programs are part of the National Postgraduate System (SNP) of Mexico's Secretariat of Science, Humanities, Technology, and Innovation (SECIHTI). For this reason, it was not necessary to request access from the authors or seek their authorization to analyze and report the results. The analysis was limited to published methodological information and did not involve contact with participants, access to primary data, or the processing of personal information not available in the documents. The identifying information for the theses has been retained because they are publicly available academic works that may be cited; however, the analysis focuses on methodological designs rather than on the individual assessment of their authors or participants.

Information regarding the methodological approaches of the 19 selected theses (design and results) was collected and organized, and then analyzed through coding and categorization. This process made it possible to identify certain characteristics of hybrid methodological designs associated with their purposes and contexts of application, as well as some common challenges and practices in their implementation.

2.1. Document Corpus Selection

The theses were chosen through the following criteria:

a) have been defended as part of a master's or doctoral program at ICE-UAEM;

b) be available for public consultation in institutional repositories or open-access academic archives;

c) include in their methodological design at least one offline data collection technique and one technique that is facilitated by digital technologies or conducted online;

d) contain sufficient information on the design, instruments, participants, context, and data collection procedure;

e) cover the 2013–2024 period, according to the theses ultimately included.

The units of analysis were the sections of each thesis that addressed methodological design, the research context, the participants, data collection techniques, the instruments used, online and offline interaction strategies, the types of data generated, and the methodological challenges reported by the researchers.

2.2. Analysis Procedure

The analysis was conducted in several phases. In the first phase, the sections of each thesis relating to methodological design were identified and extracted. In the second phase, these excerpts were organized into a hermeneutic unit to facilitate cross-comparison. In the third phase, an initial coding was performed, focusing on traditional methods, e-methods, contexts of application, the role of each technique within the design, and the challenges described. In the fourth phase, the codes were grouped into analytical categories that allowed to distinguish three types of methodological scenarios: natural, generated, and dual. These categories were compared with the literature on online research and with the characteristics observed in the analyzed theses.

Table 2. Classification criteria and roles within the different scenarios.

Type of scenario	Main criteria	Role of the researcher
Natural	The digital space or practice existed before the research	Observe, access, or analyze practices not developed through research
Generated	The digital space, activity, or dynamic is created, guided, or controlled by the researcher	Designs the environment, suggests activities, or regulates interaction
Dual	Natural and generated scenarios come together in a single design	Combines observation of pre-existing practices with designed or adapted activities

3. Results

The analysis of the studies began by identifying the various combinations of data collection techniques employed by the researchers, with the aim of determining the most frequently used e-methods and their role within the methodological designs. Table 3 provides an initial overview of the 19 degree theses reviewed in this study.

Table 3. Analyzed degree theses which include hybrid methodological designs.

Author (Year)	EP	Approach	Research design	Traditional methods	e-methods
Chin Shuang (2013)	PhDE	Mixed	Educational design	Survey Interview Observation	e-Observation
Castillo (2014)	PhDE	Qualitative	Case study	Documentary review Interview Focus group	e-Observation
Cruz (2016)	MER	Qualitative	Educational design	Observation Interview Survey Text analysis	e-Observation Multimedia analysis
Soto (2018)	PhDE	Qualitative	Case study	Documentary review Observation Interview	e-Survey e-Observation
García Luna (2018)	MER	Qualitative	Case study	Interview	e-Observation e-Interview
Jaimes (2018)	PhDE	Qualitative	Case study	Text analysis	Social Media Analysis (SMA)
Cuenca (2019)	PhDE	Qualitative	Narratives	Interview	e-Interview Digital diary e-Focus group
Sosa (2019)	PhDE	Mixed	Case study	Survey Interview Field journal	e-Observation e-Interview (digital rally)
Lira (2019)	MER	Qualitative	Educational design	Documentary revision Observation Survey Interview	e-Observation
Ibarra (2019)	MER	Qualitative	Ethnography	Documentary revision	e-Observation
Flores (2020)	MER	Qualitative	Ethnography	Interview	e-Survey Online journal
Medina (2020)	PhDE	Qualitative	Educational design	Observation Field journal	Checklist Rubric Digital diary
Cruz (2020)	PhDE	Mixed	Case study	Interview	e-Survey Digital diary
Hernández Lemus (2020)	MER	Qualitative	Case study	Observation Content analysis Focal group	e-Survey
Arellano (2021)	PhDE	Qualitative	Case study	Documentary revision	e-Survey
García Viveros (2022)	MER	Qualitative	Case study	Documentary revision	e-Interview
García Luna (2023)	PhDE	Qualitative	Case study	Documentary revision	e-Interview

Author (Year)	EP	Approach	Research design	Traditional methods	e-methods
Hernández-Levi (2023)	PhDE	Qualitative	Educational design	Interview	e-Survey e-Observation Multimedia analysis Online focus group
García Díaz Infante (2024)	MER	Qualitative	Case study	Interview	e-Interview e-Survey e-Observation

EP= Educational Program, PhDE=PhD in Education, MER=Master in Educational Research

Of the 19 theses analyzed, 10 were classified as natural settings, 4 as generated settings, and 5 as dual settings. This distribution shows the predominance of research that draws on preexisting digital environments, although it also highlights the importance of designs in which the researcher creates, adapts, or regulates digital spaces to develop educational interventions or specific data-collection methods.

Although all designs are hybrid, this study focuses in particular on the incorporation of e-methods, their contributions to research, and the challenges of their implementation, given that the literature on traditional methods is extensive.

What we consider to be our main finding in this exploration of the selected studies was the identification of at least three research scenarios associated with hybrid methodologies:

- Natural. When the online spaces and practices under study occur naturally—that is, they existed before the researcher's arrival and are not under the researcher's control.
- Generated. When online spaces and practices have been created, modified, or manipulated by the researcher so that participants will perform certain activities or engage in interactions within a controlled environment.
- Dual. When a researcher explores both natural and artificial settings.

These distinctions—at least the first two—have been identified in different, though equivalent, terms by authors such as Beninger et al. (2014). Hine (2008) raises the question of the extent to which the research site is constructed by the ethnographer and the extent to which it is a pre-existing entity. Similarly, MRS (2010, cited by Woodfield, Morrell & Metzler, 2013) proposes a distinction between naturally-occurring data on digital social media and data generated through the researcher's intervention.

3.1. Natural scenarios

Natural scenarios are characterized by access to existing digital environments that are not controlled by the researcher. Case studies and ethnographic approaches predominate in this group, especially in institutional virtual environments, digital social media, and communication platforms. E-methods primarily serve to observe, capture interactions, analyze digital content, and complement face-to-face interviews or focus groups.

The studies by Castillo (2014), Flores (2020), García Díaz Infante (2024), García Luna (2018, 2023), García Viveros (2022), Hernández Lemus (2020), Ibarra (2019), Jaimes (2018), and Soto (2018) were conducted in natural settings, following the classification proposed above. All of them (except for Flores's thesis) were case studies: in the first four, data were collected from virtual environments created and managed by third parties as part of the construction of their respective cases. These were virtual learning environments (Moodle and Teams). In all four projects, adults were observed: teachers, tutors, and undergraduate students.

In Hernández Lemus's (2020) thesis, an e-survey was used to explore note-taking and its characteristics in mathematics classes among UAEM students. The studies by García Viveros (2022) and García Luna (2018, 2023) used e-interviews via Zoom to analyze the practices and identities of UAEM faculty members with experience in online teaching, as well as those who, as a result of the pandemic, had to use communication tools to continue their teaching activities.

In the study by Flores (2020), technology-mediated e-observation—which will be explained shortly—was conducted to explore the participants' everyday use of social media.

Castillo (2014) conducted structured non-participant e-observation in two online training courses in which faculty members from the case institution under study had participated. The platforms and their users were inactive, as the courses had ended, and the researcher's task was to collect data on the various activities carried out by the participants. All of the contributions and interactions reviewed were based on texts written by the participants as part of assignments, in forums, or in other activities.

Soto (2018) conducted non-participant e-observation in virtual tutoring rooms with the aim of recording and analyzing interactions between tutors and tutees. The spaces and users observed in this case were also already inactive when the researcher accessed them and retrieved the records of all interactions that had taken place there. It is important to note that following the e-observation, the researcher administered an e-survey to the tutees consisting of open-ended questions to learn more about their opinions regarding their experience in the virtual tutoring rooms. The information gathered through both e-methods provided the researcher with a more comprehensive view of what took place during the virtual tutoring process, which constitutes one of the advantages of using e-methods, as noted by Díaz de Rada (2012).

Ibarra (2019) used non-participant e-observation in online courses hosted on the UAEM's Moodle platform, with the aim of recording and analyzing the communication interactions (synchronous and asynchronous) between students and faculty, as well as the products of the formational (instructional) design based on the use of various technological tools available in the virtual environment. In line with his objectives, the researcher was able to observe online the formal, technical, and content elements of the concept maps created by the students.

Flores (2020), who was interested in the use of digital social media for learning among non-college-aged youth, invited her participants—all adults—to keep an online journal in which they recorded their activity on digital social media. In this case, we are dealing with e-observation mediated by technology and by the participants themselves, since the researcher did not observe them directly on social media but rather asked them to engage in a process of self-observation, which they in turn shared with her.

In the case of Flores (2020), one might think that this is a generated scenario, given that the researcher asked participants to keep a digital log; however, the fact that this log was used only to record the participants' natural social media activities brings this research context closer to the premises of a natural scenario than a generated one. One aspect to consider in this hybrid research is that the face-to-face interviews with participants helped “fill in the gaps” of e-observation and allowed for further exploration and deeper analysis of the topics raised in the online component of the study.

Jaimes (2018) also conducted a study of social media through a Facebook group called “Science for Mexico—We Are CONACYT Scholars”. The purpose of the research was to analyze the academic uses present in the Facebook group of CONACYT scholarship recipients, identifying the predominant themes in information exchanges, the types of uses developed, the patterns of interaction among participants, and the elements of social cohesion that regulate the group's functioning. To this end, she employed an online social media analysis methodology, which allowed her to map social interactions and identify behavioral patterns within the network.

Hernández Lemus (2020) used an exploratory e-survey to analyze note-taking and its characteristics in mathematics classes among UAEM students. The survey was administered using Google Forms, with invitations sent via email. This approach had several advantages: it was low-cost, quick to administer, and did not require transcribing the information. The online method complemented the use of traditional methods (focus groups, observation, content analysis).

García Díaz Infante (2024) used e-interviews, e-observation, and e-surveys in her study on the habits and challenges faced by teachers in searching for, selecting, and evaluating open educational resources (OER) to integrate them into chemistry teaching and learning processes at the upper secondary level.

García Viveros (2022) conducted semi-structured e-interviews with faculty members to learn about their academic practices during the COVID-19 lockdown. The interviews were conducted via Zoom, with audio and video recordings made for transcription and analysis. Unlike other studies reviewed in this article, which incorporated hybrid methods from the outset, in this case, due to the pandemic, the student decided to change her research topic and had to collect data via videoconference (e-interviews), given the prevailing conditions.

García Luna (2023) conducted semi-structured online interviews with higher education faculty members who had experience in online teaching and with instructors who, as a result of the COVID-19 pandemic, had to use ICT to continue their academic activities. Although this research initially focused on online teaching, with the onset of the pandemic, it was decided to include in the study faculty who had to implement emergency remote teaching, in order to broaden the scope of the research.

Since the data collection took place during the pandemic, it was also necessary to conduct e-interviews via Zoom, with audio and video recordings for later analysis.

The cases of García Viveros (2022) and García Luna (2023) are typical examples of research projects that had to be conducted online or were completed in a hybrid format due to the extraordinary circumstances surrounding the pandemic. In both cases, thanks to e-methods, the researchers were able to continue their respective projects without interruption and complete their research on time and in accordance with established procedures.

3.2. Generated scenarios

The generated scenarios are primarily associated with educational designs, interventions, or research activities created to elicit specific practices, interactions, or digital outputs. In these cases, the researcher has greater control over the environment, the activities, and the conditions of participation, although he/she also assumes greater ethical and technical responsibilities.

The works by Arellano (2021), Cruz (2016), Cuenca (2019), and Medina (2020) fall into the category of generated scenarios. Both Cruz (2016) and Medina (2020) involve educational designs; Cuenca's (2019) approach is from the perspective of narratives, and Arellano's work is a case study.

Cruz's master's thesis (2016) was an educational intervention titled "Enriched Reading Circle," consisting of a social reading experience of a transmedia novel. It was conducted at a middle school in the city of Cuernavaca, in the state of Morelos (Mexico). A closed Facebook (FB) group was created for the virtual component of the reading circle, which also included a face-to-face component.

Both the closed Facebook group and the mirror space on Moodle (for participants who did not use Facebook) were used to promote activities related to reading the transmedia novel. As a closed space created specifically for participants to publish predetermined content, it constitutes a setting generated and controlled by the researcher. In this case, this was necessary as part of the educational design tested in the intervention and also to protect the participating minors. Participants posted content in various formats that often combined text and images. Analyzing multimedia data—beyond the written word—presented an additional challenge for the researcher.

Medina's (2020) case was similar, as she developed an educational intervention in which a virtual environment served as a digital repository—both for the resources made available to participants and for the submission of the various products generated during the process—although the main interaction with the group took place face-to-face in a physical classroom. The platform used was also the UAEM's LMS, Moodle. The virtual space was used as a tool for collecting information. All data—both that collected during offline sessions and that from the platform—were treated equally as "intercontextual in practice" (Leander, 2003, p. 224). The researcher drew on the perspective of Orgad (2009), who asserts that the medium from which the data originate is irrelevant. This view reflects the current reality, in which the boundaries between online and offline are becoming increasingly blurred.

The activities carried out by the online participants included a forum for sharing assignments and a digital diary. Adult undergraduate students participated in this study, and the data generated were multimedia.

Arellano (2021) conducted a study focusing on internet cafes as environments that facilitate internet access and their role in promoting digital skills among the population of the state of Morelos. The study used an online survey, which was administered in person but via computers available at the internet cafes. The research presented challenges, such as difficulty accessing the locations, the condition of the equipment, and connectivity issues.

A final example of the generated scenarios is the case of Cuenca (2019), who used two online spaces: the UAEM 's Moodle platform, where participants kept a digital diary, and a closed Facebook group that served as an e-focus group. The objective of this research was to gather participants' narratives regarding the conceptions of creativity held by professor-researchers from different universities and how these concepts relate to their academic work as teachers and researchers. The digital diary served as a space for reflection and introspection for the participants. At the same time, they were invited to participate in an e-focus group on Facebook, where the researcher served as administrator and facilitator, providing “triggers” for discussion. This space allowed for interaction among the participants, even though they were affiliated with different, geographically dispersed universities, which in turn made it possible to identify commonalities and differences across their various institutional contexts.

As some members refrained from posting, the researcher scheduled three synchronous events to encourage active conversation among everyone, so they could discuss their research contexts and practices.

Both methods—the online diary and the e-focus group (asynchronous and synchronous)—were tools that contributed to the research on three levels: a) allowed the researcher to gradually approach the participants, so that she could conduct the interviews with a broader and deeper understanding of their conceptions and opinions regarding the topic of study; b) they facilitated rapport; and c) they served as an ideal medium for capturing the participants' authentic voices, which were subsequently incorporated into narrative vignettes in the body of the thesis.

In this study, the researcher also conducted online interviews, particularly with participants who were geographically distant, which were carried out via videoconferencing.

One of the challenges of this methodological approach, given the participants' background, was, in some cases, a lack of digital skills needed to participate in the spaces that were provided.

3.3. Dual scenarios

Dual scenarios combine the observation of preexisting digital practices with activities designed or adapted by the researcher. This category is not defined by the mere accumulation of techniques, but rather by the coexistence of two methodological approaches: one aimed at recording natural practices and the other aimed at creating specific conditions for participation, intervention, or data production.

Finally, we analyzed studies conducted in dual scenarios—that is, where researchers used both natural and generated scenarios, or where they established specific dynamics for participants while allowing them the freedom to use the media of their choice. Examples of such studies include those by Chin Shuang (2013), Cruz (2020), Hernández-Levi (2023), Lira (2019), and Sosa (2019).

The theses of Chin Shuang (2013) and Lira (2019) are examples of the combination of natural and researcher-generated scenarios. Chin Shuang (2013) combined classroom observation in Mandarin classes with e-observation on an educational platform where she hosted multimedia materials she had created to complement traditional teaching. She gathered data on the experience of using these materials through student surveys, interviews with teaching staff, as well as classroom observation and e-observation on the educational platform.

In the case of Lira (2019), an initial exploratory approach to the subjects was carried out through participant observation by the researcher in closed Facebook groups created by third parties, where most of the members belonged to the hearing-impaired community. The researcher was interested in observing how hearing-impaired people communicated online, a phase that allowed him to discover common practices in their communicative exchanges, the mediated use of LSM (Mexican Sign Language), as well as the prevalent use of images and emojis.

To develop the intervention—which aimed to determine whether an online course designed according to the principles of Universal Design for Learning (UDL) met the needs of hearing-impaired students—the researcher worked with students enrolled in a technical high school program that was inclusive and provided the participation of LSM interpreters. The researcher had to create the online course in Moodle and implement it with the participants.

Unlike other implementations that used spaces created in Moodle, in this intervention—even though this LMS was also used—it was necessary to observe the participants in person, since some did not have their own devices or an internet connection at home, or required the assistance of interpreters provided by the institution due to their limited Spanish literacy skills. Thus, it can be said that the processes of observation and participatory e-observation overlapped in both space and time, since while the young people were accessing the online platform, they were receiving in-person instructions and assistance from the researcher and the interpreters.

The main challenge identified in Lira's (2019) study was the low level of Spanish literacy skills among the hearing-impaired community in Mexico and the still-prevalent reliance on written or spoken text as the primary forms of instructional design in online courses, which limits the use of certain e-methods.

Sosa (2019) used e-interviews and non-participant e-observation. In both cases, she used Facebook for different purposes and employing various strategies, which required the participants—students at a public high school in Temixco, Morelos—to accept her friendship requests on the social media platform. The e-interview was conducted using guided questions framed as a "digital rally." Participants answered the questions individually via private messages and as a group on the wall. In this case, Facebook was used so that participants could carry out activities designed and directed by the researcher; therefore, it is considered a generated scenario, even though a group was not created specifically for this purpose.

Non-participant e-observation was used to monitor their informal interactions on Facebook, with a particular focus on issues related to sexuality and gender. In this case, the setting was natural, as the researcher did not intervene in or control the participants' practices and interactions.

In this study, a major challenge was to ensure, during the face-to-face phase of the research, that the participants trusted the researcher enough to accept her as a “friend” on Facebook and allow her to observe them.

Cruz (2020) invited his participants—all adult college students—to keep a digital diary using the medium of their choice, in which he asked them to share screenshots and reflections on their various online activities throughout the day, as the research objective was to explore manifestations of their digital culture, with a particular focus on their practices related to non-academic learning. This constitutes a form of e-observation mediated by technology and by the subject of the observation themselves. Although participants were free to choose their medium, the activities were designed by the researcher; therefore, this is considered a generated scenario.

Concurrently, the researcher conducted direct e-observation in natural settings, as the participants granted him access to various social media platforms and online spaces they frequented.

Following the e-observation, the researcher conducted face-to-face interviews, as did Flores (2020), which allowed him to delve deeper into the various aspects observed.

A fourth and final case that illustrates the dual scenario is the research on educational design conducted by Hernández-Levi (2023). From its original design, this project incorporated a combination of observation and participant e-observation, based on a hybrid intervention focused on building transliteracy competencies through a participatory reading model. One of the central research interests was to observe readers' co-creation practices through their production of remixed and original content on social media platforms of their own choosing. However, the pandemic struck during the initial phase of fieldwork, and the author had to adapt his design.

The only in-person activity that could be carried out were interviews with teachers, but all work with students had to be conducted in the virtual environments provided by the educational institutions (not on social media, as originally planned). Since the research was conducted at two schools, Google Classroom was used at one and Microsoft Teams at the other. The researcher had to adapt his strategies to the environments established by each educational institution.

We classified this study as a dual scenario, since its original design incorporated social media—which might seem like a natural setting—but under guidelines established by the researcher, which gave it the character of a generated scenario. However, the design shifted toward a more natural setting (the virtual classroom) when the researcher was forced to adapt his intervention strategies to institutional spaces and dynamics that both he and the participants were required to adhere to.

From these spaces, the researcher collected cultural works in a variety of formats. Hernández-Levi (2023) also used e-surveys and e-interviews to gather additional information from the participating students.

This final case is of particular interest because, in addition to using a hybrid methodology, the researcher submitted a hybrid thesis in which most of the appendices—since they consisted of multimedia material—were presented as links to content hosted in the cloud (Google Drive). This reflects a growing trend toward multimodal, multimedia, and transmedia theses that go beyond the traditional document.

Table 4. Methodological challenges.

Challenge	Description	Scenarios where it is most prominent
Access to Participants	Difficulty accessing digital spaces, obtaining permits, or achieving sustained participation	Natural and dual
Privacy and Consent	The need to protect identity, data, and digital traces	All the scenarios
Digital Literacy	Limitations on participants' or researchers' ability to use platforms, diaries, or online tools	Generated and dual
Scenario Control	The researcher's greater or lesser ability to regulate interactions and data collection conditions	Natural and dual
Identity Verification	Difficulty in determining who actually participates in certain online spaces	Natural
Multimodal Data	Inclusion of text, images, videos, screenshots, hyperlinks, and transmedia productions	All the scenarios
Limited Choice of Platforms	Technical, regulatory, social, or institutional conditioning for the use of Moodle, Facebook, Teams, Google Classroom, Zoom, etc.	All the scenarios
Research Involving Minors	Necessity for reinforced protective measures and the utilization of closed or institutional spaces	Generated and dual

4. Discussion and Conclusions

The analysis of the 19 theses reveals three main findings. First, hybrid methodological designs are not equivalent to qualitative, quantitative, or mixed-methods approaches, but rather a way of articulating contexts, techniques, and means of collecting data both online and offline. Second, the distinction between natural, generated, and dual scenarios helps us understand the degree of control researchers have over digital spaces and the role that e-methods play within the design. Third, the main methodological challenges center on access to participants, privacy, consent, identity verification, digital literacy, and the handling of multimodal data.

Reality is complex, and our being, communicating, and acting constantly shift between in-person and online contexts, between the public and the private, which requires social researchers to exercise greater creativity and flexibility in their methodological designs so they can capture the different dimensions of their research subjects' practices in various contexts. Lévy (1999) analyzes various forms of hybridization from the perspective of the "Moebius effect" as the blurring of boundaries between various dichotomies; similarly, García Canclini defines hybridization as "sociocultural processes in which discrete structures or practices, which previously existed separately, combine to generate new structures, objects, and practices" (2009, p. 14).

The value of hybrid methodological designs lies in the ability to combine the best of both worlds—that is, to take advantage of the novelty and added value of e-methods without abandoning traditional, proven methods. The reviewed theses confirmed how researchers use combinations of methods and e-methods to complement, triangulate, and delve deeper into the dynamics of data collection and analysis. Some designs begin with an online approach and then conclude with a face-to-face approach, or vice versa: first, the offline dimension is explored, and then the analysis is deepened through e-methods. There are also cases in which e-methods are used as a means of obtaining information about the issue under study.

One consistent finding was that case studies and ethnographic studies explore natural online scenarios that existed prior to the research. In contrast, educational designs, in this case mostly associated with various manifestations of transmedia, require the design and controlled management of online spaces and activities to observe and evaluate specific aspects of the educational intervention itself and its outcomes. This necessarily involves the use of researcher-generated scenarios, although, as we saw in the case of Hernández-Levi (2023), reality sometimes dictates adjustments to the research design. This is consistent with the findings of Beninger et al. (2014), Hine (2008), and Woodfield, Morrell & Metzler (2013).

Similarly, challenges associated with e-methods were confirmed, such as sampling limited to individuals with internet access, the difficulty of verifying participants' identities, and the researcher's limited control in various situations—findings that are consistent with the arguments put forward by Díaz de Rada (2012); Frączkowska (2020); Holt (2020); and Latkovikj & Popovska (2019). Conversely, a promising aspect of e-methods is their ability to reach hard-to-reach populations, as demonstrated, for example, by studies conducted with people with disabilities (Sunderland, Chenoweth, Matthews & Ellem, 2015) or with criminal groups (Holt, 2020).

It is also evident that the flow of people between in-person and virtual environments, especially on digital social media, makes real-time or even delayed e-observation practically impossible due to the variety and dynamism of these spaces. This increasingly requires that the subjects being observed record their own online practices through digital diaries and logs, thereby transforming e-observation into e-self-observation. This requires a participant with a high degree of involvement in the research and a willingness to keep a record of their activities or practices, which is not easy to achieve. Conversely, it avoids the difficulty of asking participants for permission to track their online activities, which constitutes an invasion of privacy that not many are willing to accept.

As with traditional methods, it is essential to consider ethical issues, such as protecting participants' identity and privacy—especially in the case of minors—as noted by Machado da Costa & Francisco (2021). The involvement of minors also poses a challenge regarding the use of certain tools, which—despite having age restrictions—are used by many adolescents under the stipulated minimum age. Likewise, the use of digital social media poses a risk to minors, which the researcher must minimize through strategies such as creating closed, non-public groups. Another aspect to consider—which was identified by Hernández-Levi (2023)—is the need to use educational resources with the necessary security credentials to avoid exposing participants to unnecessary cyber risks.

An additional challenge posed by the hybrid methodological design is the volume and variety of formats of the collected data (multimedia, multimodal, transmedia), which complicates its processing and analysis; in this context, artificial intelligence tools emerge as a promising alternative (Lopezosa & Codina, 2023; Mellon et al., 2023).

Finally, it is important to recognize that, during the COVID-19 pandemic, many novice and experienced researchers were forced to adopt e-methods, suggesting that hybrid research designs will become more common in recent years and in the years to come.

This study has some limitations that should be taken into account when interpreting its results. First, the corpus comes from a single university, so the proposed typology needs to be compared with theses, articles, and projects developed in other institutional and national contexts. Second, the analysis is based on completed academic documents and not on interviews with their authors or on a review of the primary data generated by each research project. Third, the authors' proximity to part of the analyzed context may have facilitated their understanding of the research designs, but it also required a reflective reading based exclusively on documentary evidence.

Based on the analysis conducted, it is recommended that educational research using hybrid designs specify from the outset: a) the role each method plays within the design; b) whether the digital spaces are natural, generated, or dual; c) the degree of control the researcher has over the platforms and interactions; d) what ethical measures are adopted to protect privacy, consent, and identity; e) how multimodal or transmedia data will be managed; and f) what digital literacy skills are required of both the research team and the participants.

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ARTICLE / ARTÍCULO

Open Educational Practices for Critical Digital Competence: design characteristics and impact within the Spanish Higher Education Context

Prácticas Educativas Abiertas para una Competencia Digital Crítica: características de diseño e impacto en el contexto universitario español

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Abstract: Open Educational Practices (OEP) connected to both student agency and social justice enable the development of Critical Digital Competence (CDC). However, these have not been explored in depth for these purposes, nor have they been studied specifically in our context. This study aims to analyze the characteristics and impact of OEP in the Spanish university context, especially those that work primarily or secondarily with CDC. Semi-structured interviews were conducted with 12 university educators in the Spanish context. The analysis consisted of two consecutive phases: 1) the systematization of the main data from the 24 OEP identified in the interviews and 2) content analysis of the 12 educator interviews. The results show that most OEP focus on elements of CDC related to information search, analysis, processing and communication and critical evaluation of content, with other elements being less represented. Critical thinking about the digital world is presented as a cross-cutting element. Various impacts from the OEP related to competencies development can be observed, such as learning-to-learn or network collaboration. The study suggests that the open nature of OEP is not sufficient to foster critical thinking, but rather design is key to incorporating elements that promote CDC.

Keywords: Critical Digital Competence, Open Educational Practices, Higher Education, Student Agency, Open Educational Resources, Design for Learning.

Abstract: Las Prácticas Educativas Abiertas (PEA) vinculadas tanto a la actividad agéntica del estudiantado como a la justicia social permiten el desarrollo de la Competencia Digital Crítica (CDC). Sin embargo, estas no han tenido una exploración profunda para estos propósitos, ni se han estudiado de forma concreta en nuestro contexto. Este estudio tiene por objetivo el análisis de las características e impacto de las PEA en el contexto universitario español, especialmente aquellas que trabajan de forma principal o secundaria la CDC. Se emplearon entrevistas semiestructuradas, con 12 docentes universitarios del contexto español. El análisis constó de dos fases consecutivas: 1) la sistematización de datos principales de las 24 PEA identificadas en las entrevistas y 2) análisis de contenido de las 12 entrevistas docentes. Los resultados evidencian que la mayor parte de las PEA se enfocan en elementos de la CDC que tienen que ver con la búsqueda, análisis, procesamiento y comunicación de la información y la evaluación crítica de contenido, con menor representación de otros elementos. El pensamiento crítico sobre el mundo digital se presenta como elemento transversal. Se observan impactos diversos de las PEA relacionados con el desarrollo de competencias, como aprender a aprender o la colaboración en red. Del estudio se deriva que la condición abierta de una PEA no es suficiente para fomentar un espíritu crítico, sino que el diseño es clave para incorporar elementos que fomenten la CDC.

Palabras-clave: Competencia Digital Crítica, Prácticas Educativas Abiertas, Educación Superior, Agencia del estudiantado, Recursos Educativos Abiertos, Diseño para el aprendizaje.

1. Introduction

Open education has emerged as a global movement that strives to democratize access to knowledge while reshaping teaching and learning practices in Higher Education. The basis of Open Educational Practices (hereinafter, OEP) is interdisciplinary and multifaceted alike; generally understood through two core ideas: the use of Open Educational Resources (hereinafter, OERs) and the implementation of pedagogical strategies grounded in the principles of open education. Cronin (2017) integrated these two perspectives into a definition of OEPs, characterizing them as pedagogical approaches that leverage OERs to foster collaborative, participatory, empowering, and transformative learning experiences. Both OEPs and Higher Education are situated within specific sociocultural contexts, where reflection acts as a mediating process between structural influences and agency (Cronin, 2017). However, the adoption of OEPs in Higher Education institutions depends not only on the availability of open content, but also on a range of institutional, cultural, and strategic factors that significantly influence the integration thereof into the university system (Luo et al., 2019). Studies such as Morgan et al. (2021) suggest that successful initiatives call for a holistic approach integrating leadership, clear policies, institutional culture, and support mechanisms.

Furthermore, the relationship between the use of OERs and the adoption of OEPs has not been examined in sufficient depth. A study conducted by Nascimbeni and Burgos (2019) involving 724 university educators from 36 countries, found that greater use of OERs is associated with a higher likelihood of adopting OEPs. However, research on this relationship remains limited and has often focused solely on content availability, overlooking the pedagogical, organizational, and design aspects of OEPs. The academic community acknowledges the need to adopt more comprehensive approaches that examine the impact of OEPs on educational innovation and the development of sustainable ecosystems, including its relationship with student agency. In this regard, in their systematic review of student agency in Higher Education, Marín, Tur et al. (2025) conclude that the adoption of OEPs can significantly boost student autonomy and strengthen their capacity to take action. This is achieved through a range of strategies, including involving students in designing OERs, creating online content, and using technologies that give them greater control over the learning process. OEPs have the potential to transform the power dynamics around knowledge, shifting from a model in which the educator is the sole source of knowledge to one in which the educator acts as a facilitator, while students become co-producers of knowledge throughout their learning process (Andrade et al., 2011; Axe et al., 2020).

There is a need to further expand research focused on analyzing and documenting practical experiences, particularly with regard to how OEPs can contribute to fostering agency among educators and students alike. As OEP initiatives evolve and mature within educational institutions, frameworks and tools that support the design and evaluation thereof become increasingly valuable. For example, Bali et al. (2020) examine OEPs through the lens of social justice and define them based on their focus beyond OERs, including processes and students, ultimately identifying three aspects that can be combined into typologies: a) content- or process-centered, b) teacher- or learner-centered, and c) pedagogical practice- or social justice-oriented.

This view of OEPs, which links learner agency with social justice, supports the development of critical digital competence. In fact, the critical aspect of digital competence has been identified as being of utmost importance to achieve transformative change in educational practices (Gutiérrez-Ujaque, 2024) and for fostering participation and engagement in social transformation (Prinsloo, 2022). Although digital competence has been defined by the European Commission (2019) as a set of varied skills that include various nuances from a critical perspective, it is still one of the least elaborated aspects of digital competence (Gouseti et al., 2024). As a result of a systematic literature review and expert validation of a conceptual framework on Critical Digital Competence (CDC) (Marín, Esteve-Mon et al., 2026; Marín, Orellana-Hernández et al., in press), CDC is defined as the «understanding and confident, analytical, ethical, safe, and responsible use of digital technologies as value-laden tools for learning, working, and participating in society, rather than neutral entities» (Marín, Esteve-Mon et al., 2026, p. 2).

This framework also led to the identification of six interrelated aspects of CDC. The first refers to critical thinking about the digital world, encompassing an understanding of online production and consumption processes, awareness of one's own digital literacy, and recognition of the sociocultural contexts in which technologies are used, as well as the ability to participate critically in digital ecosystems. This first aspect involves paying attention to the social, political, and ethical implications of how technologies are designed and used. It also includes aspects relating to the critical reflection on AI, data-driven innovation, the ideologies underpinning digital platforms, and the power of digital media, to name but a few aspects. The second aspect addresses searching for, analyzing, processing and communicating information, including interpreting multimodal texts, synthesizing information from different sources, and recognizing power dynamics. The third aspect concerns digital citizenship and responsibilities, encompassing the critical, safe, and ethical use of technologies, including safeguarding privacy, identity management, and responsible participation in digital environments across educational, professional, and social contexts. The fourth aspect, data literacy, concerns how personal data are collected, processed, and used, as well as the development of strategies to increase data subjects' control over their data and to enable more conscious and secure information management. The fifth aspect relates to critical media production, understood as the creation of digital content (including OERs) from a transformative perspective, using multimodal forms of expression that can challenge dominant narratives and foster civic engagement. The final aspect, critical content evaluation, refers to the ability to assess the credibility, reliability, and validity of digital information.

This study presents an analysis of selected OEPs in Spanish Higher Education, according to their contribution to developing CDC and examining their characteristics and pedagogical strategies within the framework of open education. We understand that the instructional design of OEPs is a relevant and complex task for educators, as it calls for understanding the complex interrelationships between the elements that go into planning a learning activity (Buils et al., 2023; Goodyear et al., 2021; Laurillard, 2012). Design for learning, which originated in the Anglo-Saxon context, is a relatively recent concept in the literature that focuses on developing conceptual strategies and meaningful ideas for understanding how to design emergent teaching and learning activities (Carvalho & Yeoman, 2019). Through this process, educators can improve their analytical capacity and make informed pedagogical decisions regarding the design of learning activities, including the selection of appropriate tools and materials, making it a valuable educator-training resource (Goodyear & Dimitriadis, 2013).

The Activity-Centered Analysis and Design (ACAD) framework is based on the premise that learning activity should be situated and takes into account the physical, social, and epistemic elements that shape educational situations (Goodyear, 2015). To do so, it identifies four main aspects of design. Firstly, the learning scenario: designing elements in learning spaces (hybrid, online, and face-to-face), including digital tools and materials (resources, artifacts, and furniture), as well as the positioning thereof within a given space. Secondly, social interaction: refers to the design of social arrangements among students, such as groups or dyads, predefined roles, division of labor, the nature of collaboration, and students' roles in group work or assessment. Thirdly, epistemic or knowledge tasks refer to the design of learning activities, including the organization of knowledge, considerations of ways of knowing, and the selection, sequencing, and pacing of information for meaning-making. Finally, the goals: this aspect is included only when ACAD is used to plan learning objectives. In most cases, particularly in formal education, it is less likely to change.

The established, social, and epistemic components are the «designable elements» of a learning situation, meaning those elements that are open to modification or change. However, within this framework, the learning activity is not considered designable, as it is not possible to fully predict or control what students will do in advance; therefore, it is seen as emergent.

In the context of this research, the analysis of OEPs was conducted using an adapted version of the well-established ACAD framework developed by Goodyear et al. (2021) called the «ACAD CoDiCri Toolkit», developed within the framework of the project «Critical Digital Competence: towards agency for learning through open educational practices» (CoDiCri)[1]. Using a system of cards on a physical or digital canvas, this adapted instrument is designed to help educators analyze existing practices or come up with new teaching and learning proposals from the perspectives of openness, critical engagement, and student agency (Castañeda et al., 2026).

Striving to contribute to research on OEPs and its impact on CDC and agency in Higher Education, this study sets the following objectives:

a) To characterize OEPs in the Spanish context in relation to the CDC elements they incorporate.

b) To identify the impact that, according to educators, these OEPs have on developing students' CDC.

c) To take a deeper look into the relationship between the CDC elements and the ACAD-based design of OEPs.

Overall, this study strives to address the following research question: What are the characteristics and impacts of CDC-related OEPs in the Spanish university system?

[1] https://recercacompetecs.udl.cat/codicri

2. Method

This study is part of a larger design-based research (DBR) project (Easterday et al., 2018; McKenney & Reeves, 2012) (CoDiCri) focused on designing, implementing, and validating a pedagogical framework for developing OEPs in Higher Education that fosters CDC and student agency. This qualitative study draws on two prior tasks from the Analysis/Understanding phase of this DBR (reported in other publications), which are briefly described below.

On the one hand, a systematic literature review was conducted on the three central concepts of the project, of which this study highlights the relationship between two of them: OEPs and CDC. On the other hand, and concurrently, a systematic search was conducted using web scraping techniques to explore the websites of Spanish universities and assess the state of CDC, student agency, and open education in this context (Esteve-Mon et al., 2026). Among the results, 35 OEPs implemented by university educators in the Spanish context were identified.

Following this initial identification, the present study got underway. This was based on the objective of analyzing OEPs in the Spanish university system that addressed CDC and student agency. These university educators were contacted via email to request their participation in a semi-structured interview with a view to exploring how they developed OEPs in their classes and the institutional factors involved. In some cases, these educators put us in touch with colleagues who implemented OEPs that were more aligned with the project criteria. Twelve educators from eight universities (six public and two private), located in different regions of Spain, provided voluntary consent to participate in this study. The Research and Knowledge Transfer Ethics Committee of the University of Lleida issued a favorable opinion regarding the study.

The interviews were conducted between November and December 2024 and lasted approximately 30 to 45 minutes each. Prior to the interviews, the researchers shared an infographic with participating educators outlining the study's objectives and the key aspects that would guide data collection:

- Educator profile (e.g., years of teaching experience, educational level, initial training, etc.).
- Examples of OEPs (e.g., the design and use of OERs; student learning, impact of OEPs on transforming teaching practices, etc.). This is the focus of the present study.
- Institutional context (e.g., institutional policies supporting the implementation of OEPs, as well as factors that facilitate or hinder the adoption thereof within the university and its departments).

The interviews were conducted online via *Microsoft Teams*, audio-recorded, automatically transcribed, and subsequently reviewed by the research team.

Data analysis was conducted in two consecutive stages:

- Systematization of the main OEP data by drawing up descriptive sheets for each OEP. Each sheet included the following information (available on the project website): a) CDC elements (Marín, Esteve-Mon et al., 2026); b) learning scenario design (adapted from the ACAD CoDiCri Toolkit, Castañeda et al., 2026); c) OEP type according to the classification proposed by Bali et al. (2020); and d) implementation characteristics. These fact sheets were published in the institutional repository and on the project website following member checking and approval by the participating educators.

- Content analysis of the interviews supported by MAXQDA. The researchers agreed on a coding system comprising five aspects (e.g., teaching profile, ACAD, impact on learning, and the relationship between innovation, change, and institutional practices), 14 categories, and 48 codes. Four of the five researchers who conducted the interviews also participated in the collaborative analysis thereof. This second phase of the study focuses on two of the identified aspects: a) impact on learning (with the following sub-codes: impact on the development of CDC across its six elements of the conceptual framework, the development of the learning-to-learn competence, and other impacts/learning outcomes) and b) aspects of the ACAD framework that constitute the ACAD CoDiCri toolkit. To visualize relationships among these codes and sub-codes, a visual map and several co-occurrence tables were generated using the same analysis software.

This study presents the main findings derived from analyzing 24 OEPs in terms of the CDC elements identified and the types of OEPs, as well as the results of the content analysis of 12 interviews related to these OEPs. The latter focused, on the one hand, on the relationships between the CDC elements identified in the OEPs and the impact on learning perceived by educators as a result of the implementation thereof. On the other hand, it examined the relationships between the CDC elements identified in the OEPs and the design aspects according to the ACAD framework.

3. Results

3.1. EO1: Characterizing OEPs in relation to CDC in the Spanish university system

Regarding the first phase of data analysis, based on the systematization of key data from the 24 OEPs, the information on the study programs involved, the CDC elements identified (there may be more than one), and the type of OEPs are presented below.

The identified OEPs are distributed across a range of university programs (see Figure 1): 41% are in master's programs related to educational technology or digital education; 23% in initial teacher training; and 4% in continuing teacher education. Furthermore, 14% correspond to transversal practices not tied to a single course. The remaining OEPs are found in other degree programs, including Psychology (5%), Social Education (4%), and Multimedia Engineering (9%).

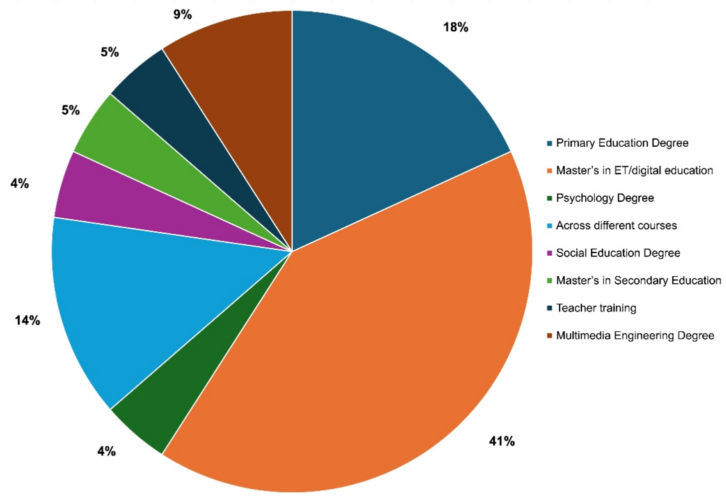

Figure 1. Location of the analyzed OEPs within Spanish Higher Education.

Regarding the 24 OEPs analyzed through semi-structured interviews with 12 educators from Spanish universities, the following CDC elements were identified in the records (first analysis): Information search, analysis, processing, and communication were identified in 16 OEPs; Critical content evaluation in 13 OEPs; Critical thinking about the digital world (awareness and reflection) and Digital citizenship and responsibility in 10 OEPs; Media production (critical perspective) in 7 OEPs; and Data literacy in 2 of the 24 OEPs.

On the other hand, regarding the types of OEPs, according to the classification proposed by Bali et al. (2020), among the 24 OEPs analyzed, the following are identified (see Figure 2): 14 were identified as Pedagogical practices focused on the learner and the content, 13 as Pedagogical practices focused on the learner and the process, 8 as Pedagogical practices focused on the teacher and the content, 5 as Pedagogical practices focused on the teacher and the process, 3 as Social justice practices focused on the learner and the content and 1 as a Social justice practice focused on the teacher and the content and as a Social justice practice focused on the teacher and the process. However, no Social Justice OEPs focused on the learner and the learning process were identified.

For example, OEPs associated with the CDC and student agency were identified, such as collaboratively editing Wikipedia, searching for, analyzing, or creating OERs as part of students' learning processes. On the teaching side, examples include developing repositories of OERs or creating OpenCourseWare courses. A detailed description of this type of OEP is provided at https://hdl.handle.net/10459.1/468262 [2].

[2] Direct translation in web format here: https://recercacompetecs-udl-cat.translate.goog/codicri/resultados/coleccion-de-casos-pea-en-el-contexto-universitario-espanol?_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=es&_x_tr_pto=wapp

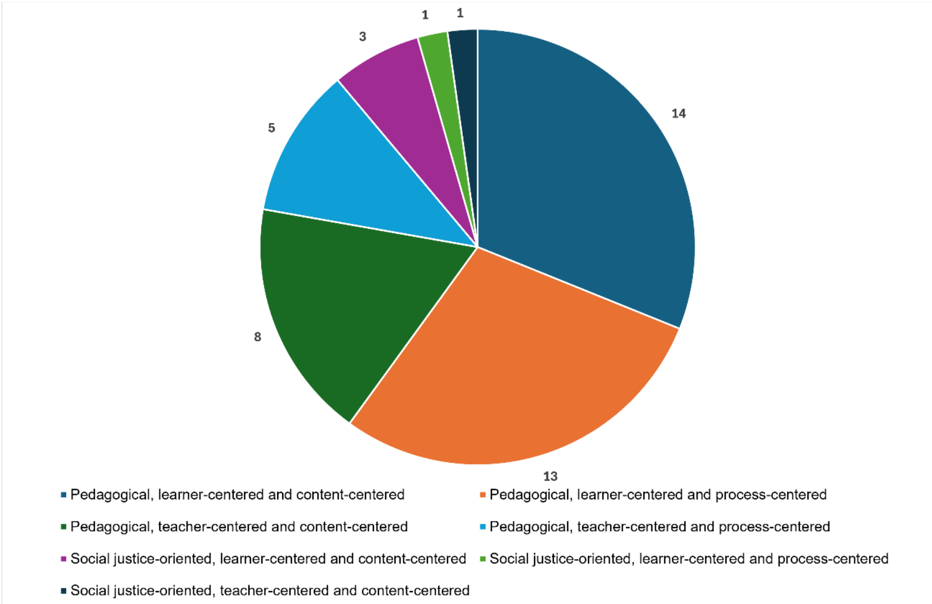

Figure 2. Types of OEPs Analyzed in Spanish Higher Education.

3.2. EO2: Identify the impact of OEPs on CDC and perceived learning

This objective was addressed through the second phase of data analysis, which consisted of the content analysis of the 12 interviews using MAXQDA. Figure 3 presents a code intersection map illustrating the relationship between the perceived impact of OEPs on CDC development (highlighting the three most frequently mentioned elements), the educators' perceived learning outcomes derived from OEPs, and the design of OEPs according to the ACAD aspects. Visualizing code co-occurrences within the same fragment provides a deeper understanding of the narratives put forward by the participating educators.

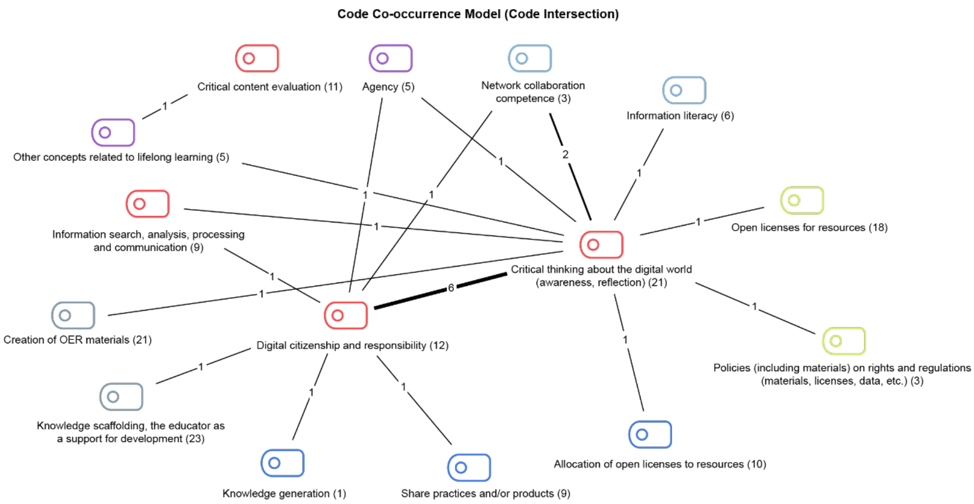

Figure 3. Code Intersection Map Linking CDC Elements, Perceived Learning Impact, and OEP Design According to the ACAD Framework

Note: Each element on the map represents a code, while the colors indicate membership in different code categories. The frequency with which each code appears across the 12 interviews is shown in parentheses. The lines connecting the codes indicate how often they co-occur in the interviews, reflecting the type of relationship.

Three CDC elements are most frequently positioned in the central and right areas of the map: digital citizenship and responsibility (n=12), critical content evaluation (n=11), and critical thinking about the digital world (awareness and reflection) (n=21). Some examples from the interviews include:

> «Open educational resources are not just materials that can be used, as in teaching practice, but also a topic of reflection and critical inquiry regarding what it means to access knowledge and how knowledge is produced. So, for me, its role is two-fold, it has a dual function.» (E12, Digital Citizenship and Responsibility)

> «The aim is to reflect on the use of this type of digital technology, its impact on people and professions, and the ethics of its use, as well as the development of materials, and, most importantly, without forgetting its technological characteristics, whether we take a step back from or make use of that technological potential, we inevitably influence the pedagogical features of the materials that are developed, and that guides us.» (E6, Critical Thinking about the Digital World)

> «Above all, it provides a starting point, an initial element developed within the university, an institution, or by an educator who is expected to have relevant knowledge. So, if we provide them with these initial, scientifically validated elements, we are giving them a high-quality starting point from which they can later navigate the vast amount of information available. It has to be evaluated critically, because there are millions that contribute very little, and some may even lead to incorrect beliefs.» (E2, Critical evaluation of the content)

The other three elements appear less frequently on the left side of the map, with fewer co-occurrences and weaker connections to other codes in the interviews. Connections are also observed among the CDC elements, with some appearing more closely related than others. The transversality of the Critical Thinking about the Digital World element is particularly noteworthy, given its high density of relationships and frequent co-occurrence with the other CDC elements.

With regard to critical thinking about the digital world, the codes linked to educators' perceived impact on learning derived from the implementation of OEPs include the development of network collaboration competence (social aspects) (5 connections), content creation (3 connections), information competence (3 connections), learning-to-learn competence (explicitly associated with the concept of agency, 4 connections), and other impacts (2 connections).

> «A sense of community, a sense of collaboration, and the idea that nobody knows everything, but everyone knows something. There is community intelligence, a form of collective intelligence. Its value is worth highlighting.» (E4, Networking Collaboration Competence)

> «I mean, we can add the 'digital' label if we want, given the environment we are in, but critical competence in general is only developed, in my opinion, when it is you who has to make decisions. That is one of the problems I consistently observe in students which I also consider needs to

> be urgently addressed. As time goes on, they become increasingly protected, in the sense of 'No, just tell me what you want and I'll do it for you. Don't ask me; I mean, you're playing a game, just decide. 'What if I make a mistake?' 'Well, if you make a mistake, you'll cope; it's not a big deal.'» (E11, Agency)

With regard to digital citizenship and responsibility, several learning outcomes are repeated, including the network collaboration competence and information literacy (three connections each), as well as the learning-to-learn competence (agency: 3 connections, autonomy: 2 connections) and other relationships with lifelong learning (4 connections).

> «And then learn the style of written communication, [...] there you analyze a lot of things. We were interested in students' critical thinking and analytical skills so that they could produce something, and that was very difficult for them. Understanding that we were not looking for text length, but for quality; text that contributes new knowledge to what already exists and that can be disseminated and presented rigorously, in line with the stylistic and ethical standards of Wikipedia itself.» (E7, Information Literacy)

> «When they design what we used to call teaching units, they consider how to adapt the syllabus and how to create and develop activities. In doing so, they must integrate methodologies, objectives, skills, and expectations.» (E12, Autonomy)

Finally, critical evaluation of content is mainly associated with the learning-to-learn competence (shown in purple in Figure 3), as well as with the development of autonomy (3 connections) and other concepts related to lifelong learning (4 connections).

> «We considered collaboration to be one of the key competencies of the program, and this activity supported it because contributions were not individual; […] participants agreed on what was published.» «But it was carried out in a rather collaborative, group-based way.» (E7, Other learning-related concepts)

3.3. EO3: To further explore the relationship between OEP design according to ACAD and CDC elements

In the second phase of data analysis, the relationships between OEP design according to the different aspects of ACAD and CDC elements were also explored, adopting a broad perspective, including identifying co-occurrences throughout the educators' narratives, thereby enabling a more in-depth examination of nuances of meaning.

Table 1 presents the co-occurrences between CDC elements and pedagogical approaches based on the ACAD-CoDiCri framework. Authentic learning (n=14) is the most frequently occurring educational framework, while critical thinking (n=19) is the most frequent CDC element. Broadly speaking, in terms of co-occurrences, it is worth highlighting that the interviewed educators' designs predominantly reflect conceptions of real and applicable (n=4), authentic (n=5), and active (n=5) learning in relation to activities addressing critical thinking. Similarly, these three learning perspectives also show the highest frequency of co-occurrence with the elements of digital citizenship and responsibility, and critical content evaluation.

Table 1. Table of co-occurrences between Pedagogical Approaches (ACAD) and CDC elements.

	PjBL	RAL	SCL	PBL	IBRL	AUL	ACL	Total
Critical thinking about the digital world	1	4	1	2	1	5	5	19
Information search, analysis, processing, and communication	0	1	1	1	0	1	1	5
Digital Citizenship and Responsibility	1	3	1	1	0	3	3	12
Data literacy	0	0	1	0	0	1	1	3
Media production (critical)	0	1	0	1	0	1	1	4
Critical content evaluation	0	3	1	1	1	3	2	11
Total	2	12	5	6	2	14	13	54

PBL = Project-based learning; RAL = Real and applicable learning; SCL = Student-centered learning; PBL = Problem-based learning; IBRL = Inquiry-based/research-based learning; AUL = Authentic learning; ACL = Active learning.

Table 2 presents the co-occurrences between the ACAD aspect of Material Resources and the CDC elements. Overall, OERs (n=21) were the most frequently identified material resource, while critical thinking was the most prevalent CDC element (n=62). Regarding co-occurrences, the association between these two elements was the most frequent (n=8), followed by co-occurrences with digital citizenship and responsibility (n=4), and critical content evaluation (n=4). Subsequently, other significant co-occurrences are those that occur between material resources such as such as Generative AI (n=5), open licenses (n=5), online platforms (n=4), and videos (n=4) for critical thinking. Also noteworthy are open licenses (n=4), online platforms (n=3) and OERs (n=4) for digital citizenship and responsibility, and the latter two for critical evaluation, along with Generative AI with n=4 repetitions each.

Table 2. Co-occurrences Between Material Resources (ACAD) and CDC Elements.

	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Blog, platform diary	3	3	3	1	0	3	13
Diverse/international/intercultural context	1	0	0	0	0	1	2
Open courses/online courses	3	1	2	1	0	1	8
Asynchronous environments	2	1	1	0	1	1	6
Physical spaces on campus/university thought for teaching and learning	1	0	0	0	0	1	2
The institution's online spaces	1	1	1	0	1	0	4
Online discussion forums	1	0	1	0	1	0	3
Sources of information – Readings – Documents of primary sources	1	1	1	1	0	1	5
Online collaborative tools	0	1	0	0	0	0	1
Online communication tools	1	0	1	0	1	0	3
Synchronous tools/environments	1	0	0	0	0	1	2
Tools for creating multimodal materials	1	0	0	0	0	1	2
Generative AI (tools)	5	2	2	1	1	4	15
Network games	1	0	1	0	0	0	2
Open textbooks	2	1	2	1	0	1	7
Open licenses for resources	5	3	4	1	1	2	16
VLE - Online Platforms	4	2	3	1	0	4	14
Multimodal materials	2	1	2	0	1	0	6
Open Educational Resources (OERs)	8	3	4	1	1	4	21
Rights and regulations policies (materials)	2	1	2	1	1	1	8

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	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Digital portfolios	1	1	1	1	0	1	5
Mixed reality resources	1	0	0	0	0	1	2
Social networks	3	2	2	1	1	2	11
Material repositories	2	3	2	1	0	3	11
Specific software	2	0	1	0	1	1	5
Online bulletin boards	0	1	0	0	0	0	1
Open Universities	1	0	0	0	0	1	2
Videos	4	0	2	0	1	2	9
Wikipedia	0	1	1	0	0	1	3
YouTube	3	1	2	0	0	1	7
Total	62	30	41	12	12	39	196

CTDW = Critical thinking about the digital world; ISAPC = Information search, analysis, processing, and communication; DCR = Digital Citizenship and Responsibility; DL = Data literacy; MPC = Media production (critical); CCE = Critical content evaluation.

Table 3 presents the co-occurrences between the social design aspect of ACAD and the CDC elements, revealing a predominance of participatory designs. Nevertheless, the designs aimed at fostering critical thinking about the digital world and critical content evaluation were evenly distributed between individual work and teamwork involving three or more participants (n=5). Furthermore, collaborative work and the involvement of educators from external contexts were notable in the development of critical thinking (n=3) and critical evaluation (n=4 and n=3, respectively). Another noteworthy co-occurrence involves collaborative groups, particularly in relation to information search and analysis (n=3), digital citizenship and responsibility (n=2), and, to a lesser extent, data literacy (n=1). Consistently, teamwork also stands out in relation to digital citizenship and responsibility (n=3) and critical content evaluation (n=2).

Table 3. Table of co-occurrences between Social Aspects (ACAD) with the elements of the CDC.

	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Collaborative groups	3	3	2	1	0	4	13
Learning community	1	0	0	0	0	1	2
Community-contextual reference group	0	1	1	0	0	1	3
Educators from other or external contexts	3	1	2	0	0	3	9
Educators within the institution/subject/course	2	1	1	0	0	1	5
Joint teams of educators and students	1	0	0	0	0	1	2
Student exercising autonomy	1	0	0	0	0	1	2
Pairs - groups of 2 people	1	0	0	0	0	0	1
External person	1	0	0	0	0	1	2
Support person - for students or faculty	0	1	1	0	0	1	3
Interviewees	1	0	0	0	0	1	2
Predefined roles	1	0	1	0	1	0	3
Teamwork - groups of 3 or more people	5	1	3	1	1	2	13
Individual work	5	2	2	0	1	2	12
Total	25	10	13	2	3	19	72

CTDW = Critical thinking about the digital world; ISAPC = Information search, analysis, processing, and communication; DCR = Digital Citizenship and Responsibility; DL = Data literacy; MPC = Media production (critical); CCE = Critical content evaluation.

Table 4 presents the broader ACAD aspect, showing a wide variety of designs and a highly distributed frequency, which reflects the diversity of tasks students engage in when working on CDC elements. Practical activities (n=16) are the most common tasks, followed by sharing practices and products (n=13), assigning free licenses (n=11), and peer collaboration (n=10), while critical thinking about the digital world (n=62), and critical content evaluation (n=48) are the most frequently occurring CDC elements. It is therefore expected that the most frequent co-occurrence occurs between practical activities and critical thinking (n=6), closely followed by the co-occurrence of the same CDC element with sharing practices and products (n=4). Other co-occurrences with three repetitions (n=3) include those between critical thinking and authentic activities, the analysis/identification of inaccuracies, the allocation of free licenses, peer collaboration, the creation and production of digital objects, and evaluation and feedback. Among the other CDC elements, three co-occurrences were observed between digital citizenship and responsibility and practical activities, the sharing of processes and products, as well as between critical content evaluation and practical activities. Data literacy and media production each show only one co-occurrence in a task, with the lowest overall frequencies (n=13 and n=8, respectively).

Table 4. Co-occurrences Between Epistemological Aspects (Students) (ACAD) and CDC Elements.

	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Real activities	3	0	1	0	1	2	7
Self-regulation and/or metacognitive activities	1	1	0	0	0	1	3
Knowledge creation activities	1	1	1	0	0	2	5
Practical activities, «doing», «creating»	6	2	3	1	1	3	16
Gamified activities	2	0	0	0	0	2	4
Activities to raise critical awareness about digital technology	1	1	1	0	0	0	3
Expression activities	1	0	0	0	0	1	2
Analysis	1	2	1	1	0	1	6
Analysis/observation of inaccuracies, biases, plagiarism, and fabricated citations	3	1	1	1	0	2	8
Allocation of open licenses to resources	3	2	2	1	1	2	11
Search and exploration of sources	2	1	1	1	0	2	7
Student-proposed activities	1	0	0	0	0	1	2
Choose topics/areas of interest	1	1	2	0	1	1	6
Decision-making capacity, curriculum, evaluation	1	1	1	1	0	1	5
Peer collaboration	3	2	2	1	0	2	10
Share practices and/or products	4	2	3	1	1	2	13
Creation and production of podcasts, artifacts, etc.	3	1	1	0	0	2	7
Knowledge curation	1	1	1	1	0	1	5
Debates, dialogues, discussions	1	1	0	0	0	1	3
Diary… portfolio, blog	1	1	1	0	0	2	5
Editing Wikipedia articles	0	1	1	0	0	1	3
Writing, drafting, narrative compositions	2	1	1	1	0	2	7
Tool evaluation	1	2	1	1	0	1	6
Self-assessment and feedback (self- or peer-to-peer)	3	2	2	0	1	1	9
Knowledge generation	1	1	1	1	0	1	5
Interaction with other agents outside the classroom	2	0	0	0	0	2	4
Virtual/face-to-face exchanges	1	0	0	0	0	1	2
Games	1	0	1	0	1	0	3
Multimodal reading	1	0	0	0	0	1	2

	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Active participation	1	0	1	0	1	0	3
Open presentation of results	2	1	2	1	0	1	7
Digital activism	1	0	0	0	0	1	2
Critical thinking	1	2	1	0	0	2	6
Flipped classroom tasks	1	0	1	0	0	0	2
Technical skills development tasks	2	0	0	0	0	1	3
Tasks for developing the own PLE	0	1	1	0	0	1	3
Informed decision-making	2	0	1	0	0	1	4
Total	62	32	36	13	8	48	199

CTDW = Critical thinking about the digital world; ISAPC = Information search, analysis, processing, and communication; DCR = Digital Citizenship and Responsibility; DL = Data literacy; MPC = Media production (critical); CCE = Critical content evaluation.

Table 5 presents the epistemic tasks defined by the ACAD-CoDiCri framework for teaching staff in relation to the six CDC elements. In this case, it is noteworthy that co-creation and co-design are scarcely mentioned by the interviewees. Undoubtedly, the most frequent activity is the creation of OER materials across all CDC elements, particularly for critical thinking about the digital world (n=7), followed by search and analysis (n=3), digital citizenship and responsibility (n=3), and critical content evaluation (n=4). It is particularly noteworthy that scaffolding knowledge-related tasks rank just behind creating OERs, showing up across critical thinking (n=4), information search and analysis (n=3), digital citizenship and responsibility (n=4), and content evaluation (n=3), along with formative assessment (n=5, 3, 4, and 4, respectively) and dialogic feedback (n=4, 2, 3, and 3, respectively).

Table 5. Co-occurrences Between Epistemological Aspects (Educators) (ACAD) and CDC Elements.

	CTDW	ISAPC	DCR	DL	MPC	CCE	Total
Knowledge scaffolding	4	3	4	1	1	3	16
Student support	1	0	0	0	0	1	2
Co-creation and co-design	0	1	0	0	0	0	1
Creation of OER materials	7	3	3	1	1	4	19
Formative assessment	5	3	4	1	1	4	18
Dialogic feedback	4	2	3	0	1	3	13
Customization	2	0	2	0	1	0	5
Receive support to understand how to develop their own OERs and the 4Rs of OERs	2	1	1	1	0	2	7
Fostering participation	3	1	1	0	1	2	8
Content curation	1	1	1	0	0	2	5
Total	29	15	19	4	6	21	94

CTDW = Critical thinking about the digital world; ISAPC = Information search, analysis, processing, and communication; DCR = Digital Citizenship and Responsibility; DL = Data literacy; MPC = Media production (critical); CCE = Critical content evaluation.

4. Discusión y conclusión

OEPs in Higher Education are recognized for their potential to improve participation, foster equitable access, and democratize learning opportunities (Murphy, 2013), while also contributing to social justice (Bali et al., 2020). Despite widespread awareness and interest, the adoption of OEPs in Higher Education remains variable. Many institutions face significant challenges, including the lack of sustainable policies, limited institutional support, and insufficient awareness among educators and students alike (Stagg et al., 2023). This is also the context in Spanish Higher Education (Santos-

Hermosa et al., 2020), where there is limited recognition and few incentives to create and use OERs, meaning they are rarely considered in teaching evaluations, which in turn discourages educator engagement. Despite these challenges, OEPs provide an ideal framework for fostering the development of CDC, which is of utmost importance for citizens to navigate complex environments and participate actively in modern society.

The convergence of the different frameworks in this study contributes to educational research and raises new challenges for future work aimed at further exploring the lines of inquiry initiated here. On the one hand, while open education has been associated with greater opportunities for students to engage critically with educational proposals and resources (Nascimbeni and Burgos, 2019), the use of the Bali et al. (2020) three-axis conceptualization, together with the six CDC elements, allows for a more detailed understanding of this relationship. Broadly speaking, the interplay between these two frameworks has made it possible to highlight the alignment between a learner-centered pedagogical approach, both in terms of content and process, and a critical perspective, encompassing the search, analysis, processing, and communication of information, as well as the evaluation thereof, along with broader aspects related to awareness of the digital society and responsible, engaged citizenship. Hereafter, the challenge lies in understanding the students' perspectives in these experiences with a view to assessing the actual impact of CDC development based on the core principles of the implemented OEPs.

Furthermore, the pedagogical analysis based on the adaptation for CoDiCri of the ACAD model provides rich insights into the design elements used, from which new challenges for educational practice and research may emerge. Firstly, the strong presence of OERs across two aspects of the ACAD framework stands out, confirming the conceptual tensions identified in relation to OEPs (Paskevicius et al., 2018), and, although OERs are often criticized for their limited impact on educational improvement (Irvine et al., 2021), they also constitute a key element in the transition towards OEPs (Koseoglu and Bozkurt, 2018). In this transition from OERs to OEPs, it is observed that, when understood as material resources, they are often used as the basis for developing awareness of the digital world and critical evaluation skills. When OERs are associated with teaching tasks, their role in fostering reflection on the digital world and responsibility is reinforced, while also highlighting their value as tools for critical information search and evaluation, thereby contributing to informational digital teaching skills. This is particularly relevant when it comes to transferring these findings to the professional development of educators across other educational levels. OERs as an object of epistemic tasks for students shows a wide diversity of designs across all CDC elements, suggesting strong alignment between student OER creation and the development of CDC competencies.

Broadening the perspective, it is important to highlight other key elements of the ACAD design framework used to analyze OEPs in relation to the CDC. In this case, it is worth noting that educators' epistemic role is shifting towards an open educator profile (Nascimbeni and Burgos, 2016), not only through the openness of teaching and learning processes but also through open assessment practices, including student co-evaluation and the provision of feedback and scaffolding in knowledge construction. It highlights that, in content creation, educators are primarily focused on developing OERs as rich instructional materials that foster learner autonomy (Tur et al., 2025) and enable flexible, personalized educational approaches (Pérez-Garcías et al., 2022). This open teaching role aligns with a particularly active and leading role for students, who exercise their autonomy and activate their agency by participating in developing the various tasks (Pérez-Garcías et al., 2022; Marín, Tur et al., 2025). Regarding the social design aspect, it is worth noting that it primarily comprises proposals with a strong social component, including pair work, small and medium groups, and highly collaborative formats. This suggests that CDC skills foster debate and exchange among agents and peers, and that, as a result, the open context of OEPs is well suited. This broadly social design is consistent with the presence of social media in the tools and designs, and the alignment thereof with all CDC elements. In this case, beyond the initial hypothesis of its suitability for the CDC, potential difficulties can also be foreseen, as suggested by the findings of Esteve-Mon et al. (2021) on the superficial level of critical reflection on social networks. Therefore, it would be particularly valuable in future implementations to assess the quality of students' critical perspectives when participating in networks within new OEP frameworks for CDC.

In conclusion, this study contributes to the literature on OEPs in the Spanish university system, while also offering insights into student learning, educational design, and the development of CDC. The analysis conducted allows for the identification of certain CDC elements present in educators' designs; however, the limited presence of practices fostering social justice suggests, in line with Bali et al. (2020), that openness alone is not enough to foster critical awareness. Instead, such practices must be intentionally designed to avoid neutrality and achieve a transformative impact.

As a limitation of this study, it should be noted that it is based on the analysis of 24 OEPs developed by 12 educators from Spanish universities. The results cannot be generalized and do not represent all universities or the broader Spanish university system. Nevertheless, the research has exploratory and descriptive value within the broader CoDiCri project. On the other hand, qualitative content analysis, although guided by a defined coding system, involves a degree of interpretation that may have led to the omission of relevant elements. However, the member-checking process with educators and the cross-researcher review of coding are highlighted.

The next phases of the project will focus on designing and analyzing new OEPs that look at CDC elements in Higher Education, as well as on educators' perceptions of their institutional impact. Future studies could entail collaborating with Higher Education professionals from other countries to obtain more generalizable data on OEPs focused on CDC development in universities.

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ARTICLE / ARTÍCULO

Digital platforms for management and teacher autonomy: perceptions of primary school teachers

Plataformas digitales de gestión y autonomía docente: percepciones del profesorado de Educación Primaria

Fernando Fraga-Varela & Inés Ramos-Trasar

Abstract: This study analyses the perceptions of primary school teachers regarding their autonomy and professional development in the context of the implementation of the LOMLOE (Organic Law on the Modification of the Organic Law on Education), as well as its possible relationship with their level of teacher digital competence. A mixed sequential exploratory design was used, involving focus groups and a questionnaire administered nationwide. The focus groups revealed difficulties perceived by teachers due to increasing bureaucratisation, overload in assessment processes, and the mandatory use of digital management platforms in what has been identified as a process of educational platformisation perceived as a control mechanism. The questionnaire (n = 872) showed that, although teachers in this context continue to value their autonomy in the classroom positively, they consider that there are difficulties in managing curricular elements, mainly due to assessment criteria. Taking into account the certification of teacher digital competence, the highest levels are associated with greater use of technological resources, but no differences are apparent in the perception of autonomy or professional development, suggesting an excessively instrumental approach to accreditation processes. It is concluded that the LOMLOE, despite aiming to promote the professional autonomy of teachers, in practice generates new forms of administrative control that put pressure on their professional development.

Keywords: Professional Autonomy, Professional Development, School Law, Teachers, Elementary Education.

Resumen: Este estudio analiza las percepciones del profesorado de Educación Primaria sobre su autonomía y desarrollo profesional en el contexto de la implementación de la LOMLOE además de su posible relación con su nivel de Competencia Digital Docente. Se empleó un diseño mixto secuencial exploratorio mediante grupos focales y un cuestionario aplicado a nivel nacional. Los grupos focales revelaron dificultades percibidas por el profesorado debido a la creciente burocratización, la sobrecarga en los procesos de evaluación y el uso obligatorio de plataformas digitales de gestión en lo que se ha identificado como un proceso de plataformización didáctica percibido como un mecanismo de control. El cuestionario (n=872) mostró que, aunque el profesorado en este contexto sigue valorando positivamente su autonomía en el aula, considera que existen dificultades por la gestión de elementos curriculares fundamentalmente por los criterios de evaluación. Tomando en consideración la certificación de la Competencia Digital Docente del profesorado, los niveles más altos se asocian con mayor uso de recursos tecnológicos, pero no se aprecian diferencias en la percepción de la autonomía o el desarrollo profesional, lo que sugiere un enfoque excesivamente instrumental en los procesos de acreditación de la Competencia Digital Docente. Se concluye que la LOMLOE, pese a pretender promover la autonomía profesional del profesorado, genera en la práctica nuevas formas de control administrativo que tensionan su desarrollo profesional.

Palabras-clave: Autonomía Profesional, Desarrollo profesional, Legislación escolar, Profesorado, Educación Primaria.

1. Introduction

The Spanish educational system has undergone successive legislative reforms over the past few decades which have substantially altered the role and working conditions of teachers. The passing of Organic Law 3/2020, of 29 December, amending Organic Law 2/2006, of 3 May, on Education (Spanish abbreviation: LOMLOE), and Decree 157/2022, of 1 March, establishing the Decree of Minimum Educational Content in Primary Education, are the current working framework for autonomous community curricula and subsequent work in schools. This reform seeks to reverse certain aspects of the previous Organic Law 8/2013, of 9 December, for the Improvement of Education Quality (Spanish abbreviation: LOMCE), promoting a competence-based approach with greater autonomy for schools and teachers. However, the curricular structure promoted was called into question, as it undermined professional autonomy by specifying the minimum learning outcomes in the form of learning standards derived from assessment criteria. Research studies have regarded this configuration as an element that devalues teachers' work, and as a loss of their professional autonomy (Rodríguez-Martínez, 2014). In consequence, the LOMLOE (2020) eliminates learning standards, reorganises the integration of competencies into areas through specific competencies linked to basic knowledge, and allows teachers to establish the minimum outcomes to be achieved in their teaching programmes. All of this is done with a view to reducing the burden of prescriptiveness.

In Spain, curriculum development is partially decentralised through a mechanism that gives autonomous communities the ability to enrich the curriculum in a percentage that varies between 40% and 50%, depending on whether the territory has or not its own co-official language (LOMLOE, 2020). The core of the curriculum is still the responsibility of the Ministry of Education in order to guarantee compatibility and coherence in the whole of the state. However, recent research (Fraga-Varela et al., 2024) has identified major inconsistencies between autonomous community curricula derived from the LOMLOE, with significant differences in terms of length, terminology and conceptual development, and especially in relation to the role of the assessment criteria proposed in the different areas.

All this information has been extremely valuable to back up the project from which this work has stemmed, whose objective was to develop a piece of software for primary education classrooms with a view to improving English pronunciation. It was necessary to understand the professional context of foreign language teachers in order to adjust the core of the educational planning included in the software and to ensure that it was adapted to the actual characteristics of the teaching without becoming an obstacle for teachers already overloaded with administrative tasks. In this regard, previous work for the project identified a wide variety of ways of developing autonomous community curricula, and showed a trend to increase the average number of assessment criteria, with a total of 415 from the autonomous communities, compared with 287 from the Ministry. Extreme cases can be seen, such as that of Galicia, which has established 1,312 criteria, which means a 4.6-fold increase compared with the Decree on the Minimum Educational Content, or Castile and León, with 873 criteria, which triples the number stated in the same decree (Fraga-Varela et al., 2024). These data point to a clear tendency to overregulation of teachers' work.

This overload in the development processes of autonomous community curricula is also apparent in the area of English as a Foreign Language. While the Decree on Minimum Educational Content proposes 43 assessment criteria for the entire primary education stage, communities such as Galicia have established 82 criteria (91% more), with distributions that multiply especially in the first cycle, going from 13 criteria to 43 (a 230% increase). A study on teaching programmes in Galician schools (Trillo and Fraga-Varela, 2023) revealed the extraordinarily high number of elements of assessment that teachers must manage in their programmes, with an average of 40 criteria per didactic unit and approximately 400 criteria for the whole of the academic year in the same area. All this is in addition to the need to collect evidence for each selected criterion for all students on the basis of the assessment tool established.

1.1. Teacher professional development as reference

Teacher professional development (TPD) is the core concept of this study. We understand TPD as a continuous set of processes throughout teachers' working life which, taking initial training as a basis, extends through lifelong training to tackle the different challenges of professional practice in both formal and informal settings (Montero-Mesa et al., 2023). TPD is the goal of any training action, laying the emphasis on the improvement of teachers' ability to face the complexity and uncertainty of teaching (Schön, 1998).

This approach embraces the conception of teachers as researchers of their practice with the ability to produce knowledge (Admiraal, 2024; Tardiff, 2013), highlighting the importance of the way in which professional knowledge is built. Professional autonomy emerges as a key element for teachers to be able to exercise this role as researchers and act in a manner that reveals reflection on their practice (López-Arias & Sánchez-Moreno, 2023; Schön, 1992).

But this is not merely a matter of research. The European Commission has insisted on the need to reinforce teachers' competences and foster their autonomy to achieve quality education (European Commission / EACEA / Eurydice, 2021), which is currently recognised as a trend in European educational systems (European European Commission / EACEA / Eurydice, 2025). However, educational policies tend to relate quality exclusively to accountability and external assessments, placing professional autonomy in a merely instrumental setting linked to control, which results in contradictions with what it really involves (Pérez Gómez, 2014).

The tension between a bureaucratic, administrative conception and a professional, pedagogic one (Bolívar, 2019) becomes more acute when educational legislation moves towards new forms of control that may devalue teachers' work, affecting their qualification and status. Barroso (2006) has analysed how school autonomy can become mere rhetoric when, simultaneously, regulatory and control mechanisms by education authorities are stepped up. The doubt as to whether genuine autonomy is being guaranteed persists: are we facing a real possibility for TPD or new ways of preventing it?

1.2. Overregulation and performativity in teaching practice: the opportunity of teacher digital competence in the face of new forms of control

The international literature has identified instances of overregulation of teaching practice through assessment and accountability mechanisms. Ball (2001, 2003) has analysed how global policy guidelines translate into local policies that transform teachers' professionalism into new forms of managerialism and performativity. In this context, assessment becomes highly relevant, as it evolves into an objective of performativity and has a direct impact on how teachers' work is perceived at present (Pardo Baldoví, 2025).

Parcerisa and Falabella (2017) have documented the consolidation of what they have called the 'evaluative state' through accountability policies that, while promising improvements, often limit professional autonomy. The emphasis on assessment and the substantial increase in the elements that vertebrate it, especially as a result of all the assessment criteria that teachers have to manage, evidence this tendency to overregulation of professional practice by the authorities. In a context of external assessments and accountability, assessment processes become the core of performativity (Ball, 2003), which has a direct impact on the way in which teachers' work is regarded. Assessment criteria become a symbolic element that transcends what is evident, externalizing school activities and establishing themselves as a central component of teachers' work, as they focus their practice on providing evidence and justification to administrative control systems rather than on pedagogic reflexion.

In this context, the platforms that the authorities establish as mandatory for managing teaching programmes reinforce the situation described above. This is an extension of platformisation (Kerssens and van Dijck, 2021; Kerssens and van Dijck, 2022; Nieborg et al., 2022) but one in the field of education, as it contributes to the processes by which digital platforms restructure practices and relations in different sectors (Poell et al., 2019). This situation in the field of education cannot be treated merely as yet another form of surveillance capitalism (Zuboff, 2019) since, as Williamson (2020) points out, it is essential to analyse its distinctive forms, practices and consequences in this field. This is a phenomenon that entails the adaptation of teachers to new modes of regulation imposed by education authorities through digital tools that set new mechanisms for controlling and homogenizing teaching practice. As mandated by authorities, platforms claim this space for educational and curricular matters (Sefton-Green, 2021; Williamson et al., 2025).

In this context, it is necessary to look at teacher digital competence (TDC) based on DigCompEdu (Redecker, 2020), whose regulatory basis in Spain is the Resolution of 4 May 2022, which proposes aspects that go beyond the mere use of technologies and may constitute a clear opportunity to strengthen TPD. This is the largest coordinated training initiative in our country in recent years which depends on one single reference structure. The framework includes lifelong professional digital development, reflective practice and general teaching elements such as teaching planning, assessment and professional reflection processes. Area 1 of TDC (INTEF, 2022) focuses specifically on professional commitment, including organisational communication, professional collaboration, reflective practice and lifelong professional digital development.

However, the question arises of how teachers are experiencing their TPD at present, and if the improvement in TDC constitutes an opportunity for their professional development and autonomy in light of the contradictions detected at curricular level as a result of the implementation of the LOMLOE and the use of new digital support structures. This work presents a review of the data of the project, investigating these emerging elements that were not envisaged among the initial objectives. In today's context, it is a priority to understand the role of digital technologies in teaching practice, and the difficulties to go beyond merely instrumental aspects and embark on a true educational transformation. In such context, this work has the following objectives:

a) To identify the factors that teachers perceive as limiting teacher autonomy and TPD in the framework of the LOMLOE.

b) To analyse the extent to which the available training meets teachers' actual needs.

c) To examine the relationship between TDC certification and teachers' perception of their autonomy and professional development.

2. Method

2.1. Research design

A mixed-methods sequential exploratory design (Creswell and Plano, 2018) was used, structured into two main phases, which makes it possible to complement the depth of the qualitative analysis with the breadth of the quantitative analysis. The qualitative phase enables an in-depth exploration of teachers' perception in a context of high overregulation of the curriculum in the autonomous communities, and the quantitative phase contextualises these findings. It is important to note that the qualitative results are exploratory and limited in scope, and they cannot be generalised to teachers as whole. The entire process was approved by the Bioethics Committee of the University of Santiago de Compostela under code USC 08/2023.

2.2. Qualitative phase: focus groups

An initial qualitative phase was developed through the design of focus groups with teachers from a variety of primary schools. Among these focus groups, this work has taken into consideration those that took place in Galicia, as they provided information on the objectives of this study identified as DG1 for discussion group 1 and DG2 for discussion group 2.

For the design of the focus groups, the type of school (public or private, and rural or urban) and the involvement of teachers with different levels of teaching experience were considered. The intention was to explore in depth their perceptions, experiences and concerns in relation to professional autonomy, bureaucratisation and professional development in the context of the LOMLOE. Based on these considerations, two focus groups were carried out in Santiago de Compostela: one in a public school and one in a private charter school. Each group consisted of eight teachers, ensuring gender parity. Also, with a view to having a comprehensive perspective, profiles with different careers were selected.

The focus groups were conducted following a semi-structured script that considered three main categories: the first, at classroom level, on the implications for teachers, which dealt with the elements that primary education teachers face in their daily work; the second, at school level, with elements such as professional autonomy, accountability policies and levels of curriculum concretion; and the third, at education stage level, that tackled fields such as bottom-up programming, the relationship with other areas, assessment, competence development and project-based work.

Participation was voluntary, and anonymity and confidentiality were guaranteed through the use of identification codes. The sessions lasted for approximately 90 to 120 minutes, were recorded in audio with the previous written consent of the participants, and were subsequently transcribed for their analysis. The transcriptions underwent an emerging analysis following an inductive–deductive process that included the following phases: familiarisation with the data through the iterative reading of the transcriptions, and writing down initial ideas. The initial coding was subsequently performed (using in vivo coding and the manual assignment of codes) by means of the systematic identification of relevant fragments, which resulted in a total of 69 codes. Next, themes were sought by grouping codes according to the study objectives. The themes were then reviewed and refined, ensuring their identification, delimitation and naming, laying the emphasis on internal coherence.

Lastly, a report was prepared by selecting representative excerpts and integrating them into the theoretical framework for presenting them in the frame of the project. The qualitative analysis software Atlas.ti (version 25) was used to facilitate data management and coding.

2.3. Quantitative phase: questionnaire

Subsequently, and based on the previous findings, a second, quantitative phase was carried out that used a nationwide questionnaire addressed to primary education teachers as technique, to obtain more detailed information on the quantitative findings in a larger, more representative sample.

The questionnaire included an initial section on sociodemographic and professional variables (autonomous community where the teachers carried out their professional practice, type of school and level of TDC certification), and a second section with 5-level Likert scales (1 = Strongly disagree; 5 = Strongly agree) organised into four dimensions: sociodemographic data; pronunciation; from the law to the reality of the classroom; use of resources for the teaching of a foreign language and, lastly, the work environment of the teachers. Once the questionnaire had been designed, it was validated through expert review. These dimensions respond to the context of the project from which this work has stemmed; therefore, based on the objectives guiding it, the fields that were not relevant, such as pronunciation or the use of resources, were not taken into account in the results.

To contact the teachers, a national list was prepared using the website of the Ministry of Education by identifying schools that met the established criteria, which totalled 14,080. A bot was implemented in R (R Core Team, 2024) to extract information by inspecting websites using a web browser and, for the questionnaires, using Postman to analyse requests. HTTP POST or GET requests were made according to the architecture of the site to obtain email addresses through the rvest library (Wickham, 2024). Detailed HTTP headers were configured (User-Agent, Accept-Language, Cookies) to simulate browser requests, establishing a 5-second delay between requests to prevent server overload. The questionnaire was sent on 14 October, 4 November and 25 November 2024 at a rate of 60 emails per hour with a minimum of 5 seconds between emails to comply with usage policies and avoid spam. The responses were compiled anonymously, with each email including a specific hash to maintain traceability and make it easier to cancel the subscription. Depending on the autonomous community, the emails were sent in Spanish, Galician, Basque or Catalan after obtaining the necessary permits. After receiving responses or cancellations, the database was updated by removing the corresponding emails in the next round. The response rate of the survey was 5.6%, which corresponded to 713 schools from a total population of 12,732, and a total of 875 individual responses from teachers. After applying the sample estimation formula with correction for a finite population, the sample obtained showed a margin of error of ±3.6 percentage points for a level of confidence of 95% and under the assumption of maximum uncertainty ($p = q = 0.5$). This margin is below the conventional threshold of ±5 percentage points that is normally accepted in education research, which suggests adequate sample precision. However, these results should be interpreted with caution in view of the potential limitations resulting from the response rate. Cronbach's alpha showed acceptable internal consistency ($\alpha = 0.78$), exceeding the reference value of 0.70 (Medrano and Pérez, 2019) and confirming the coherence of the items.

The data were analysed using IBM SPSS Statistics 27.0. Descriptive analyses were carried out, which included means, standard deviations, frequencies and percentages for all variables. Prior to the comparative analyses, the assumption of normality was verified using the Kolmogorov–Smirnov test, whose results indicated that the distributions of the variables did not follow a normal distribution ($p < 0.05$). Consequently, the non-parametric Kruskal–Wallis test was used to compare the groups by level of TDC certification, as this constitutes the robust alternative to the ANOVA of a factor when the assumption of normality is not met. A significance level of $p < 0.05$ was established for all the analyses.

3. Results

3.1. Focus groups

The analysis of the focus groups carried out with teachers in Galicia revealed some difficulties in teachers' perceptions of teacher autonomy and professional development in the context of the LOMLOE. Based on the in vivo and manual coding of the transcriptions of the focus groups, a code group table (Table 1) and a network representation of the most relevant quotes and codes were created, enabling a visual structure of the qualitative analysis performed (Figure 1). This section includes also some of the teachers' statements collected (in the form of quotes) from the two focus groups.

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Table 1. Emerging code groups from the in vivo and manual coding of the transcriptions.

Code groups	Codes
Context	teachers in Galicia, Galicia, primary education, LOMLOE, TPD, school law.
Bureaucratisation and control	bureaucratisation, bureaucratic elements, bureaucratic justification, administrative management, administrative control, forms of control, digital control and surveillance mechanisms, accountability, administrative demands, imposition, obligation, certification.
Educational platformisation	educational platformisation, digital management platforms, PROENS platform, mandatory tools, automation, automated prescription, work logic, models.
Teaching practice and programming	teaching practice, daily practice, planning, teaching programmes, didactic units, preparation, monitoring, plans, resources, digital resources, innovation.
Assessment	assessment criteria, assessment tools, assessment processes, quantitative weights.
Impact and concerns	discontent, overload, workload, frustration, obstacles, limitation, autonomy, contradiction, conditioning, educational value, perceptions, experiences, concerns, difficulties, perceived difficulties.

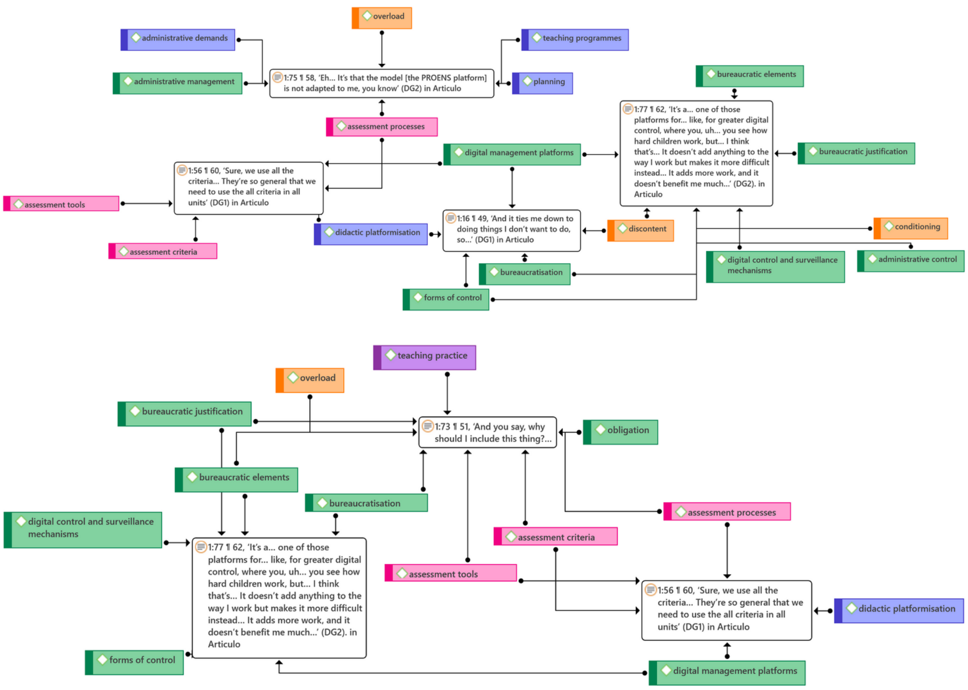

Figure 1. Network of quotes and emerging codes from the coding of the transcriptions of DG1 and DG2.

Bureaucratisation as professional limitation

Teachers express recurrently their deep discontent with the growing bureaucratisation of their teaching work, a phenomenon that is perceived not only as administrative overload but also as a direct limitation of their professional autonomy. This conditioning is summarised in some of the participants' statements: 'And it ties me down to doing things I don't want to do, so…' (DG1).

This perception of a 'tie' becomes more intense in light of the obligation to manage a high number of often disproportionate assessment criteria established by the curricula of the autonomous communities. Teachers state that they must incorporate criteria that they consider to be of little relevance or unsuitable for their practice; they are obliged to include these criteria owing to administrative demands and to the structure of the mandatory platform that manages teaching programmes. Their discomfort is apparent: 'And you say, why should I include this thing? And you jolly well have to include it, because all of them have to be included' (DG1).

This obligation generates frustration because teachers perceive that many of these bureaucratic elements are not related to their daily practice in the classroom and become administrative tasks that take up their time without adding educational value: 'I know you need to work with them, and… Why should I quarrel with anybody. If you have to do it, you have to do it. But sometimes these are things that don't have… any… that don't have any application in my daily practice' (DG1). This administrative logic is also evident in the obligation to prepare and deliver multiple plans that guide school work (digitalisation plan, coexistence plan, reading plan, etc.) and, above all, in the requirement to follow extremely detailed teaching programmes in which assessment criteria play a central role and have a profound impact on teaching planning and development.

Educational platformisation as control mechanism

A key finding of the focus groups is what we have called 'educational platformisation': the imposition of digital platforms for educational management as mandatory tools for the preparation and monitoring of teaching programmes. This is the case of the PROENS platform in Galicia. Teachers clearly note that these tools are not adapted to their way of working; instead, such tools force them to adapt their work to the predefined logics and structures of the platform: 'Eh… It's that the model [the PROENS platform] is not adapted to me, you know' (DG2). The impact of these logics is twofold: on the one hand, these platforms automate processes prescriptively, as is the case of the automatic connection of contents (or basic knowledge) with assessment criteria, which limits teachers' professional flexibility to make connections that are more in line with their specific educational reality. On the other hand, the platforms make it mandatory to link each assessment criteria to specific assessment tools and to establish minimum levels of achievement and quantitative weights for each criterion. This, together with the high number of criteria, generates a workload that is perceived as excessive and unnecessary. Teachers' statements underscore the inefficiency and overload that result from this process: 'Sure, we use all the criteria. They're so general that we need to use all the criteria in all units' (DG1).

As a result, processes focus on assessment and bureaucratic justification, weakening the importance of contents and making classroom work less of a priority compared to administrative management. Teachers perceive these platforms not as facilitators but as mechanisms of digital control and surveillance of their work: 'It's a… one of those platforms for… like, for greater digital control, where you, uh… you see how hard children work, but… I think that's… It doesn't add anything to the way I work but makes it more difficult instead… It adds more work, and it doesn't benefit me much…' (DG2). This creates a systemic contradiction: technological tools, presented as innovative, facilitating tools, are experienced as obstacles that increase the workload without providing significant educational benefits, and that act mainly as accountability and administrative control devices.

3.2. Quantitative results: questionnaire

The data of the questionnaire provide an overview at national level that offer a perspective that complements and qualifies the qualitative findings. Table 2 presents the means and standard deviations of the main items related to autonomy and professional development.

Table 2. Perceptions on autonomy and professional development.

	M	SD
I can introduce digital resources in the classroom	4.17	.898
I have the necessary TDC	3.85	.981
I am worried that I may not have the knowledge	2.70	1.382
I have professional autonomy at classroom and school level	4.03	.903
I am autonomous in terms of resources	4.36	.774
I am concerned about how little room there is to adapt the curriculum	3.79	1.070
I have the necessary training for the curriculum	3.99	.852
The training meets the existing needs	2.90	1.071

The results confirm the tension identified in the focus groups, with the difference that greater teaching autonomy is perceived in general (M = 4.36) and also for decision making in the classroom (M = 4.03). This situation may be due to the exceptional characteristics of the curriculum in Galicia as a result of the level of overregulation it establishes in assessment processes. Teachers believe that they have the necessary training to address the demands of the current curriculum (M = 3.99). However, they express a moderate to high degree of concern about there not being enough room to adapt the curriculum (M = 3.79), which suggests that their perceived autonomy occurs within strongly prescribed limits. In a complementary fashion, they assess the available training as not really suited to their actual professional needs (M = 2.90). This is the item with the lowest rating and the greatest dispersion (SD = 1.15), which indicates a significant disconnect between the training activities on offer and actual professional demands.

The analysis of the differences in perceptions according to the level of TDC certification reveals relevant findings. Table 3 presents the compared means of three groups of TDC established in the study: level A (A1–A2 certification), level B (B1–B2 certification) and level C (C1–C2 certification).

Table 3. Perceptions according to the level of TDC certification.

	Level A (n = 273)		**Level B** (n = 456)		**Level C** (n = 143)				
	M	**SD**	**M**	**SD**	**M**	**SD**	**H**	**p**	**r**
I can introduce digital resources in the classroom	4.05	.924	4.24	.871	4.17	.914	8.176	.017*	0.097
I have the necessary TDC	3.59	.993	3.96	.955	4.02	.945	32.347	.000*	0.193
I am worried that I may not have the knowledge	2.92	1.387	2.62	1.368	2.56	1.377	10.170	.006*	0.108
I have professional autonomy at classroom and school level	4.02	0.870	4.02	.936	4.09	.863	.700	.705	0.028
I am autonomous in terms of resources	4.33	0.757	4.36	.794	4.41	.744	1.814	.404	0.046
I have the necessary training for the curriculum	4.00	0.829	3.96	.853	4.03	.891	1.387	.500	0.040
The training meets the existing needs	2.92	1.049	2.88	1.059	2.91	1.156	.211	.900	0.016

*p<0.05

The application of the Kruskal–Wallis test reveals statistically significant differences between groups in the variables directly related to technological skills:

- Ability to introduce digital resources: teachers with higher levels of TDC certification show greater confidence in their ability to incorporate digital resources into the teaching [$H(2) = 8.18$, $p = 0.017$, $r = .10$]. These differences are more palpable between level A ($M = 4.05$) and level B ($M = 4.24$) and not as much for level C ($M = 4.17$), with the latter being, curiously, that with the highest certification level. This seemingly contradictory result may be due to the fact that, in many cases, C1 level certification is obtained ex officio for the work and the duties performed in the school (in the case of Galicia, the Order of 1 June 2023, regulating the procedure to certify TDC, can be consulted). This does not mean that this level actually reflects a perceptible improvement in terms of competence. Self-perception of TDC: as the certification level increases, so does the perception of having the necessary digital competence [$H(2) = 32.35$, $p < 0.001$, $r = 0.19$]. Teachers at level C ($M = 4.02$) report a significantly higher degree of self-perception than those at level A ($M = 3.59$), with a small to medium effect size.

- Concern about one's technological knowledge: the highest certification levels are associated with less concern about not having sufficient knowledge of digital resources [H(2) = 10.17, p = 0.006, r = 0.11]. Teachers at level C (M = 2.56) show less concern than those at level A (M = 2.92).

However, it should be highlighted that no statistically significant differences were seen between levels of TDC certification in the variables linked to professional autonomy, professional development or the suitability of the training (p = 0.05 in all cases):

- Teaching autonomy: the differences between groups were minimal and non-significant [H(2) = 0.70, p = 0.705, r = 0.03; mean range: 4.02–4.09).
- Autonomy for resource management: no differences were observed between certification levels [H(2) = 1.81, p = 0.404, r = 0.05; mean range: 4.33–4.41).
- Necessary training for the curriculum: no significant differences were found [H(2) = 1.39, p = 0.500, r = 0.04; mean range: 3.96–4.03).
- Suitability of the training for the existing needs: the results show clear homogeneity across groups [H(2) = 0.21, p = 0.900, r = 0.02; mean range: 2.88–2.91).

These findings suggest that TDC certification is significantly associated with instrumental and technological aspects, such as the use of resources and confidence in the use of tools, but not with the key pedagogic dimensions of professional development, such as autonomy, reflection on one's own practice, or the perception of the suitability of the training. This questions the approach of TDC training and certification processes, as they seem to prioritise technological skills over comprehensive teaching skills, in spite of the fact that the reference framework explicitly includes the latter in its Area 1 (professional commitment).

4. Discussion and conclusions

This study was intended to explore the perceptions of primary education teachers on their autonomy and professional development in the context of the LOMLOE. To this end, the factors that teachers perceive as limiting their autonomy were identified, the suitability of the available training for their actual needs was analysed, and the relationship between TDC certification and teachers' perception of their own practice was examined.

The results obtained provide significant empirical evidence on each of these objectives, which suggests a complex and sometimes contradictory scene in terms of conditions of TPD. The findings indicate that teachers in this context perceive a tension between their recognised formal autonomy and their actual autonomy in the exercise of their duties in the classroom. While they usually consider that they are free to manage their job, they also experience limitations that stem from bureaucratisation and administrative control mechanisms, which burden their work with exhaustive assessment criteria. This task of providing justification seems to consume an amount of their time that, in teachers' view, takes them away from the immediate needs of the classroom. Moreover, the digital platforms that are mandatory for educational management are presented as elements to facilitate one's work, and yet they are experienced as control and surveillance mechanisms that homogenise teachers' practice and limit their professional flexibility.

Additionally, there is a significant gap between the available training and teachers' actual professional needs, with training that is perceived as excessively oriented towards bureaucratic compliance and an instrumental view, rather than towards educational transformation. The analysis of the questionnaire data segmented by TDC level shows differences in the instrumental domain of digital technologies; however, no changes in TPD are seen between levels of certified competence. Consequently, teachers do not feel that these processes result in a change of perception of their autonomy or professional development. These data might even suggest the adoption of an approach that is more technologically-oriented than pedagogically-oriented (Bolívar, 2019). The results confirm the tension identified by Barroso (2006) between autonomy as administrative rhetoric and its practical materialisation. The LOMLOE promises greater professional autonomy and reduced prescription, but its implementation, especially in the context of autonomous communities with high levels of overregulation, generates conditions that limit teachers' effective autonomy.

The distinction that emerges between formal autonomy (capacity to decide on methodologies and resources in the classroom) and effective autonomy (existence of actual conditions to exercise that capacity: time, suitable training and absence of bureaucratic overload) is critical. Teachers have the former, but often lack the latter, which generates an experience of limited autonomy that has a negative impact on their professional development and, potentially, on teaching quality. The extraordinary emphasis on assessment criteria, identified in previous studies (Fraga-Varela et al., 2024) has direct, significant consequences for teachers' perceptions and working conditions, as the qualitative data reveal. Assessment criteria become symbolic elements that go beyond their educational role, legitimizing mechanisms to externalise and control school activities, as has been analysed in the literature on the evaluative state (Parcerisa and Falabella, 2017). This situation exemplifies the performativity described by Ball (2001, 2003), where teachers' work is progressively oriented towards demonstration and justification to accountability systems instead of towards pedagogic reflection on teaching–learning processes. When teachers must manage 400 assessment criteria in one academic year in one area (Trillo and Fraga-Varela, 2023), justify their selection, link those criteria to specific instruments and establish weights for each student, the cognitive, time and emotional burden takes them away from their practice and towards complex administrative management. Teachers express this clearly: they must include and assess criteria that they consider irrelevant because such criteria are mandatory, even if they are completely invalid in the classroom.

The phenomenon identified as 'educational platformisation' is a significant contribution of the study that extends the analyses of Poell et al. (2019) to the specific field of educational management, as Williamson (2020) points out. Mandatory platforms represent a development in administrative control (Pangrazio, 2025), as they mark a transition from curricular prescription to algorithmic prescription. The automatic linking of curricular elements, the obligation to establish quantitative weights, and the standardisation of processes significantly reduces the room for the situated professional judgement that characterises quality teaching (Schön, 1992). Instead of adapting the system to their practice, teachers must adapt their practice to the system, inverting the logic of the service that technology should provide.

Platformisation steps up accountability by constantly making teaching work visible, thus functioning more as a surveillance device than as a pedagogic tool (Williamson et al., 2025). This transformation of teachers' professionalism towards new forms of managerialism and technical control confirms Ball's analyses (2003) of how management technologies redefine professional work.

The results show that the conditions for TPD are seriously compromised. Imbernón (2020) has identified reflection on one's practice, research–action, collaboration between professionals and educational innovation as the core components of TPD. However, when teachers spend too much time on bureaucratic tasks and managing assessment criteria, their capacity to engage in these reflective, transformational processes is limited, as the focus groups show. TPD is reduced to formal compliance with administrative requirements such as certifications, participation in mandatory courses or documentation of training activities, instead of becoming a reflective process that transforms teachers' practice. The perception that the available training does not meet their actual needs confirms such disconnect: a range of training activities in line with administrative priorities that does not meet the needs that emerge in teachers' professional practice.

Lastly, it should be noted that the findings on TDC reveal significant problems that call the approach that prevails in training processes into question. TDC certification is significantly associated with instrumental and technological aspects (capacity to use resources, confidence in the use of tools and less concern about technological knowledge) but not with the key educational dimensions of professional development. The TDC reference framework (INTEF, 2022) explicitly refers to professional commitment in its Area 1, which includes organisational communication, professional collaboration, reflective practice and professional development. However, our data show that teachers with higher certification levels do not perceive any differences in relation to these domains. This suggests that training and assessment processes to obtain TDC certification prioritise instrumental technological competencies over comprehensive educational competencies, thus reproducing historical criticism of educational technology integration policies: technological determinism, which assumes that the mere fact of mastering digital tools automatically improves educational practice.

The analysis of the results allows us to conclude that the implementation of the LOMLOE, in spite of aiming at educational improvement and greater professional autonomy, has generated, in practice, a complex, contradictory landscape for primary education teachers. The research reveals a tension between formal autonomy and effective autonomy, as well as the central, performative role of overregulation and bureaucratisation of teachers through assessment processes and the activation of educational platforms that increase these processes.

Our work suggests a number of recommendations:

a) Effective reduction in curricular prescription: revision of the number of assessment criteria, especially in autonomous communities with high levels of overregulation.

b) Auditing the bureaucratic burden of teachers: conducting exhaustive audits of the administrative requirements imposed on teachers and removing those that do not add effective educational value and respond mainly to control logics.

c) Reorientation of TDC training: reorienting teacher digital competence training and certification programmes towards comprehensive teaching dimensions, not solely technological dimensions of an instrumental nature.

d) Addressing the emerging challenges of the platformisation of educational practices at educational institutions themselves, ensuring the participation of all the persons involved, paying particular attention to teachers' reflections in relation to their autonomy and professional development.

This study has limitations that should be taken into account when interpreting its results. As both the focus groups and the questionnaire are based on teachers' self-perceptions in the context of the autonomous community of Galicia, the findings cannot be extrapolated to the whole of Spain. Consequently, we suggest that future research studies complement this approach through direct observations in the classroom, an analysis of teaching programmes, or interviews with management teams and education authorities, with a view to obtaining a deeper, holistic perspective on the subject of the research.

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ARTICLE / ARTÍCULO

Development of TPACK among Pre-Service EFL Teachers: Cooperative Learning Readiness

Desarrollo del TPACK en futuros docentes de inglés como lengua extranjera: disposición hacia el aprendizaje cooperativo.

Alireza Karbalaei & Hamid Heydari

Abstract: Effective technology integration in English as a Foreign Language (EFL) instruction requires pre-service teachers to develop robust Technological Pedagogical Content Knowledge (TPACK) frameworks to incorporate technology in EFL instruction. However, effectively improving this integrative knowledge poses a persistent challenge in pre-service teacher education, particularly in resource-limited settings. The present study sought to evaluate the role of cooperative readiness, which is considered as the preparedness to cooperate and adapt within a group in progressing TPACK among Iranian pre-service EFL teachers enrolled in final-year programs at three public teacher training institutions in Tehran. In this explanatory sequential mixed-methods study, the quantitative phase included 120 pre-service teachers who completed validated scales evaluating TPACK and cooperative readiness. The results indicated that cooperative readiness is a significant predictor of TPACK, explaining a substantial share of its variance. The qualitative phase including semi-structured interviews with 15 participants provided deeper insights into this relationship. Thematic analysis identified three key mechanisms through which collaboration fosters the development of TPACK by facilitating the dialogic co-construction of integrative knowledge through peer negotiation and reflection, alleviating technological anxiety and creating a supportive environment for experimentation, and adapting theoretical knowledge to real-world classroom constraints by serving as a bridge. Empirically, the findings indicated the synergistic relationship between collaborative competence and technological-pedagogical expertise, while practically suggesting that teacher education programs should extend beyond standalone technology courses and deliberately design collaborative learning experiences to effectively prepare pre-service teachers for the demands of technology-integrated language instruction.

Keywords: Preservice Teacher Education, English (Second Language), Second Language Instruction, Cooperative Learning, Technology Integration, Mixed Methods Research, TPACK.

Resumen: La integración efectiva de la tecnología en la enseñanza del inglés como lengua extranjera (EFL) requiere que los futuros docentes desarrollen marcos sólidos de Conocimiento Tecnológico Pedagógico del Contenido (TPACK) para incorporar tecnología en la instrucción de EFL. Sin embargo, mejorar eficazmente este conocimiento integrador plantea un desafío persistente en la formación inicial docente, especialmente en entornos con recursos limitados. El presente estudio buscó evaluar el papel de la disposición cooperativa, entendida como la preparación para cooperar y adaptarse dentro de un grupo, en el progreso del TPACK entre futuros docentes iraníes de EFL matriculados en programas de último año en tres instituciones públicas de formación docente en Teherán. En este estudio de métodos mixtos de diseño secuencial explicativo, la fase cuantitativa incluyó a 120 futuros docentes que completaron escalas validadas para evaluar su TPACK y disposición cooperativa. Los resultados indicaron que la disposición cooperativa es un predictor significativo del TPACK, explicando una proporción sustancial de su varianza. La fase cualitativa, que incluyó entrevistas semiestructuradas con 15 participantes, proporcionó una comprensión más profunda de esta relación. El análisis temático identificó tres mecanismos clave a través de los cuales la colaboración fomenta el desarrollo del TPACK: facilitando la co-construcción dialógica del conocimiento integrador mediante la negociación y reflexión entre pares, aliviando la ansiedad tecnológica y creando un entorno propicio para la experimentación, y adaptando el conocimiento teórico a las restricciones reales del aula al servir como puente. Empíricamente, los hallazgos evidenciaron la relación sinérgica entre la competencia colaborativa y la experiencia tecnológico-pedagógica, mientras que, desde una perspectiva práctica, sugieren que los programas de formación docente deben trascender los cursos aislados de tecnología y diseñar deliberadamente experiencias de aprendizaje colaborativo para preparar eficazmente a los futuros docentes ante las exigencias de la enseñanza de idiomas integrada con tecnología.

Palabras-clave: Formación inicial del profesorado, Inglés como lengua extranjera, Enseñanza de segundas lenguas, Aprendizaje cooperativo, Integración de la tecnología, Investigación de métodos mixtos, TPACK.

1. Introduction

The widespread integration of technology has fundamentally transformed contemporary teaching and learning paradigms. Digital instruments are currently utilized in educational contexts, providing enhanced accessibility and user-friendly interactions (Mexhuani, 2025). However, the influence of such technologies on enhancing student learning requires further investigation (Kosmas & Zaphiris, 2023). In EFL settings, this integration is often achieved through Computer-Assisted Language Learning (CALL), which applies mobile applications, online platforms, and virtual environments to create more continuous, collaborative, and reflective learning experiences (Zain & Bowles, 2021).

Integrating technology into the classroom remains a significant concern for teachers. Teachers should learn to work with digital instruments during their teaching, highlighting the significance of the Technological Pedagogical Content Knowledge (TPACK) framework (Tseng et al., 2022). This model proposes that effective technology incorporation requires a synergistic interplay between Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). The absence of any single component may lessen teaching efficacy. Research consistently positions, TPACK is considered a vital determinant of teacher preparedness in technology-rich classrooms (Li, 2025).

This phenomenon holds significance in milieus such as Iran, where educators often struggle with reconciling traditional methodologies with digital innovations and where infrastructural constraints significantly shape technology adoption patterns (Karbalaei, 2025). Additionally, reflective practice and accumulated classroom experience are essential to nurture the organic development of TPACK (Maor, 2017).

Despite the inclusion of educational technology courses in teacher training programs, a critical gap remains regarding how cooperative readiness—conceptualized as the preparedness to cooperate and adjust within a group—influences the development of TPACK among pre-service EFL teachers (Belda-Medina & Calvo-Ferrer, 2022). The potential interdependence of such constructs has not been empirically examined, despite theoretical suggestions. This connection plays a crucial role, as collaboration during group instruction and practicum experiences may improve pre-service teachers' flexibility and self-efficacy in employing technology to develop authentic instructional scenarios (Gurvitch & Metzler, 2009).

This dynamic is particularly salient in developing nations such as Iran, where educational technology remains unevenly distributed. The continued reliance on traditional instructional methods by in-service teachers, often stemming from insufficient training or resources, creates an environment where collaborative learning among teacher candidates proves crucial (Ouyang et al., 2021).

Pre-service teachers who engage in teamwork can cooperatively overcome anxieties, exchange innovative ideas, and identify meaningful applications for technology (Kim, 2025; Ottenbreit-Leftwich et al., 2012). This study seeks to examine the role of cooperative readiness in advancing TPACK among prospective EFL teachers, filling a gap in understanding collaboration dynamics within the TPACK model in EFL teacher education.

The TPACK framework builds on Shulman's (1986) concept of Pedagogical Content Knowledge (PCK), which highlights that effective teaching involves transforming subject matter knowledge into pedagogically meaningful forms adapted to the needs of diverse learners. The digital era has extended this knowledge to include technology. However, resistance to technology adoption continues due to cultural factors, inadequate professional development, or skepticism about the efficacy of digital learning (Abbasi Kasani et al., 2020). Obstacles such as scarce training, poor infrastructure, and the absence of modern devices further inhibit enactment.

While student feedback and blended learning models offer promising pathways for integration (Benade, 2015; Singh et al., 2021), enacting these approaches within the education context of Iran is impeded by unfamiliarity with LMS platforms and infrastructural insufficiencies (Chenari et al., 2024). Critically, teacher education programs rarely provide integrated training that links technological proficiency with collaborative pedagogical reflection—a combination essential for success in modern classrooms.

Drawing on evidence from STEM and language education, technological confidence, coupled with collaborative and reflective practices, emerges as a key conditioning factor for robust TPACK development (Chai, 2018; Yildiz Durak et al., 2023). The present study aims to address this gap by probing the juncture of cooperative readiness and TPACK within Iranian EFL teacher education. By elucidating this relationship, the results can inform the design of more effective training programs which prepare teachers for technologically constrained settings. Training pre-service teachers with collaborative and technological skills signifies an essential step toward nurturing educational quality (Lim et al., 2011).

Ultimately, this research offers actionable insights for curriculum designers, teacher educators, and policymakers in Iran, advocating for an integrated, socially embedded approach to teacher development. The following questions are applied to explore the issue through quantitative and qualitative research approaches within a mixed-methods design: (1) To what extent does cooperative readiness predict TPACK among pre-service EFL teachers? (2) How do pre-service teachers perceive that collaborative experiences facilitate the development of their TPACK?

1.1. Literature review

Incorporating technology into EFL pedagogy has catalyzed a significant shift in instruction and learning methodologies. This study synthesizes current scholarship to identify the key factors that condition TPACK development in initial teacher education, with particular emphasis on cooperative readiness as a socially embedded catalyst.

Technological Frameworks and TPACK Development in Initial Teacher Education

The current EFL classroom is progressively characterized by the integration of digital instruments such as mobile applications, LMS, and virtual simulations. These resources potentially boost flexibility, interactivity, and learner engagement by facilitating self-paced learning beyond the restrictions of the physical classroom (Ahmed et al., 2025). However, the efficacy of such instruments, especially for novice learners, remains a point of scholarly dispute. Research indicates that novice teachers require heightened autonomy and digital literacy to apply these tools effectively, otherwise technology may hinder rather than enhance motivation and comprehension (Ting, 2015).

Teachers can use CALL to teach different instructional aspects, from grammar to conversation, through Mobile-Assisted Language Learning (MALL), virtual reality platforms, and AI-driven chatbots (Solak, 2024). This expansion supports basic Second Language Acquisition (SLA) theories, which include constructivism, sociocultural theory, and interactionist approaches, highlighting knowledge construction through meaningful social interaction, reflection, and authentic contextual learning.

Mishra and Koehler (2006) presented the TPACK framework, building on Shulman's (1986) concept of PCK to offer a structured approach for teachers exploring this complex landscape. TPACK indicates that effective technology incorporation requires an integrative and reflexive awareness of the relationship between CK, PK, and TK. This fundamental model was later advanced into seven interconnected constituents, where TPK, TCK, and PCK coalesce to form the comprehensive TPACK needed for effective instruction (Tseng et al., 2022).

Empirical studies confirm that self-efficacy and pedagogical reasoning strongly predict TPACK proficiency, suggesting that technical access alone is insufficient without structured developmental support (Yildiz Durak et al., 2023). Although blended learning models have demonstrated promise in enhancing student engagement (Singh et al., 2021), their implementation in contexts like Iran remains constrained by infrastructural limitations and insufficient preparatory training (Chenari et al., 2024).

Teacher readiness, reflection, and imperative for collaboration

The successful application of technological frameworks depends heavily on the teacher, despite their potential to offer an essential structure. Studies propose a persistent gap between technological access and instructional application (Looker, 2010). For example, research in EFL settings revealed that even teachers with strong subject matter knowledge often lack the confidence to effortlessly integrate technology into their lessons (Aydin, 2013), indicating that holding knowledge of technology differs from possessing the knowledge to teach efficiently with technology.

Such a gap highlights the sustained significance of Shulman's (1986) PCK concept, which underscores the transformation of CK into instructionally powerful forms adjusted to student needs. Recent applications of the Refined Consensus Model (RCM) demonstrate that effective teachers develop this integrative knowledge through continuous reflection and peer-supported classroom experimentation, rather than isolated skill acquisition (Carlson et al., 2019; Rojo et al., 2024).

To bridge the gap between theory and practice, scholars emphasize the significance of enhancing cooperative readiness, conceptualized as a teacher's preparedness to collaborate, exchange ideas, and adjust within a professional community (Matsko et al., 2020)— a dynamic particularly salient in Iranian EFL contexts, where prior research documents how collaborative scaffolding mediates technology integration amid resource constraints. Because TPACK is fundamentally a socially constructed and context-dependent framework, its development thrives on reflective dialogue and collaborative practice rather than isolated technical training. Training programs, which separate technological skills from collaborative and instructional reflection, fail to prepare teachers for the realities of the classroom (Quintana & Fernández, 2015). Bañados (2006) argued that incorporating training on collaboration with technology plays a vital role for success in blended or online milieus. Pre-service teachers participating in teamwork during practicum or group projects build the flexibility and mutual problem-solving skills essential to overcome technological and teaching challenges, thereby directly strengthening their overall TPACK.

Synthesizing the literature, digital tools and TPACK frameworks lack transformative power when deployed in isolation (Maor, 2017; Tseng et al., 2022). Transforming EFL instruction, especially in resource-constrained settings, requires intentional pedagogical design. Teachers should be armed with integrative frameworks while developing their competence for cooperation, reflection, and adaptive practice. Consequently, teacher education programs must be deliberately structured to interweave technological training with sustained collaborative inquiry, thereby cultivating practitioners who are both technologically proficient and pedagogically responsive (Kim, 2025; Ottenbreit-Leftwich et al., 2012).

2. Methodology

This study employed a mixed-methods approach was selected to explore the relationship between cooperative readiness and TPACK among Iranian pre-service EFL teachers. The explanatory sequential design was adopted, encompassing a two-stage approach in which quantitative data collection and analysis informed a subsequent qualitative phase intended to expand, clarify, and contextualize the initial numerical results. This approach was selected to systematically identify statistical patterns while simultaneously elucidating the underlying meanings and lived experiences of the participants.

The quantitative phase engaged a correlational survey model to measure variables and assess potential relationships, while the qualitative phase used semi-structured interviews to provide depth, nuance, and explanatory power. The following sections describe the research design, participants and setting, data collection instruments and procedures, and comprehensive analytical strategies engaged for quantitative and qualitative datasets.

2.1. Research design

The explanatory sequential mixed-methods design structured this inquiry. The first phase, comprising the collection and analysis of quantitative data from a wider sample of pre-service teachers, aimed to quantitatively measure self-reported levels of TPACK and cooperative readiness, evaluate the nature and strength of the relationship between these constructs, and examine the influence of demographic variables such as age, gender, and teacher training center.

The study entered its qualitative phase upon completion of the quantitative analysis. This phase was deliberately planned to build upon the initial results. Participants were selected from the initial pool based on their quantitative responses to guarantee a diverse range of perspectives. This phase sought to probe the lived experiences of the pre-service teachers through in-depth, semi-structured interviews, and investigate the reasons behind the statistical trends observed. For instance, the interview protocol was adjusted to explore the impact of collaboration on the development of the TPK domain when the quantitative data discovered a strong correlation between collaborative motivation and this specific knowledge. This design aimed to attain a form of meta-inference, where incorporating both datasets presents a more complete and robust understanding than either could provide in isolation.

2.2. Participants and setting

The quantitative phase utilized 120 Iranian pre-service EFL teachers from three major teacher training centers situated in Tehran. Participants were selected applying a convenience sampling method, with the main criteria being their registration during the final year of the teacher education program. This sampling strategy was adopted due to logistical constraints and institutional accessibility; however, it is explicitly acknowledged that convenience sampling limits the statistical generalizability of the findings to broader populations of pre-service teachers.

Consequently, the quantitative results should be interpreted as indicative of predictive trends within this specific educational context rather than as universally representative. This phase sought to guarantee that all of the participants experienced significant theoretical training and fulfilled a minimum of one supervised teaching practicum, providing a practical basis to reflect on their knowledge and readiness. The participant group encompassed native Persian speakers (Mean age = 26.4 years, SD = 3.1).

A purposive sampling strategy was employed to select a sub-sample of 15 individuals for the qualitative interview phase. The selection criteria were planned to capture maximum variation and depth of understanding. Participants were selected to represent high and low scorers on the TPACK and cooperative readiness scales in order to guarantee a balance of gender and institutional representation, with selection constrained to those who formerly expressed willingness to participate in further research. The qualitative sub-sample comprised 72 female and 48 male participants, aged, with proportional representation from all three training centers.

Each interviewee had completed at least one full teaching practicum, ensuring sufficient classroom exposure to reflect meaningfully on technology integration challenges. Such a careful approach to sampling for the qualitative phase ensured that the subsequent data are rich, offering meaningful explanations for the wider trends acknowledged during the first phase.

2.3. Data collection

Data were collected during two different phases, corresponding to the two stages of the research design. For the quantitative phase, two main instruments were implemented digitally to all of the participants. The first was a modified version of the TPACK scale developed by Baser et al. (2016), encompassing 38 items, each rated on a five-point Likert scale ranging from strongly disagree to strongly agree.

To establish content validity, the instrument underwent rigorous expert review by three senior EFL teacher educators and two educational technology specialists, who evaluated item clarity, cultural appropriateness, and alignment with the TPACK framework. Minor linguistic adjustments were made based on their feedback prior to administration. The instrument was planned to operationalize and measure all of the constructs in the TPACK framework, including TK, PK, CK, PCK, TCK, TPK, and TPACK. Sample items explored a respondent's capacity to address student progress through technology or their ability to select appropriate instructional methods for their subject matter.

The second instrument was a Cooperative Readiness Scale, created by the research team based on the established theoretical frameworks. Similar to the TPACK scale, content validity was established through a structured expert panel review process, followed by a pilot test with a distinct group of pre-service teachers (N=20) to assess structural clarity, item relevance, and internal consistency.

This 30-item scale, engaging a five-point Likert response format, was designed to measure three core aspects: motivational readiness (which addresses intrinsic drive to collaborate), behavioral readiness (which gauges active collaborative behaviors such as listening and sharing), and cognitive readiness (which captures beliefs about the efficacy of collaboration). Prior to large-scale distribution, pilot testing confirmed acceptable internal consistency reliability ($\alpha > 0.70$) across all subscales, providing preliminary psychometric evidence of the instrument's adequacy for this context. Feedback from the study was adopted to improve item wording, and statistical analysis was conducted to ensure high internal consistency reliability across all of the subscales.

The qualitative phase of data collection used semi-structured interviews. An interview protocol was developed specifically to act on the main results arising from the quantitative analysis, which guaranteed that the qualitative data directly evaluate and help clarify the early conclusions.

The interviews were intended to be flexible, allowing for analytical questions to probe interesting themes emerging throughout the conversation. All of the interviews, implemented in Persian to foster comfort and eloquence, were audio-recorded with permission and continued between 30-45 minutes. Finally, the recordings were transcribed verbatim to create a complete textual dataset for analysis.

2.4. Data analysis

Data analysis represented the two-phase structure of the collection process. The quantitative data, collected through the digital surveys, were analyzed utilizing SPSS version 26. The analytical process started with descriptive statistics, including means, SDs, and frequency distributions to summarize the demographic characteristics of the sample, as well as describing the general levels of TPACK and cooperative readiness. Then, inferential statistics were engaged. Prior to hypothesis testing, normality and homoscedasticity assumptions were verified.

Subsequently, a Pearson correlation analysis was implemented to examine the relationships between the main variables of interest, cooperative readiness (with its sub-dimensions), and TPACK (including all of its constituent domains). Further, independent samples t-tests and one-way analysis of variance (ANOVA) were scheduled to explore any significant differences in scores based on categorical demographic variables such as gender or training center affiliation. A probability value of less than .05 was regarded as the criterion for statistical significance.

The qualitative data, including the verbatim interview transcripts, were investigated applying a systematic thematic analysis approach following the iterative process outlined by Braun and Clarke (2006). This included an immersive and repeated reading of the transcripts to guarantee familiarity with the depth and breadth of the responses. Meaningful patterns and notable elements within the data were systematically coded. Then, the codes were grouped into potential primary themes, which were checked against the original data extracts and the entire dataset to ensure their impact on forming a coherent and accurate narrative.

The last step included defining the essence of each theme and selecting vivid, demonstrative excerpts from the transcripts to include in the reporting. Strategies including member checking (where participants could confirm the interpretations of their interviews) and peer debriefing, containing discussions with fellow researchers to refine the emerging themes, were combined into the process to improve the trustworthiness and credibility of the qualitative analysis.

The final phase of analysis, which involved incorporating the two datasets, occurred during interpreting and discussing the study. The themes established from the qualitative interviews were employed to explain, illustrate, and present rich context for the statistical relationships recognized in the quantitative survey. For example, a significant correlation was reported between two variables through the participants' comprehensive accounts of their experiences, providing a deeper insight into the underlying mechanisms and rationale for the initial numerical results.

3. Results

This study aimed to examine the TPACK levels among Iranian EFL pre-service teachers, explore the role of cooperative readiness in TPACK development, and determine the potential of cooperative readiness to predict the effective application of TPACK. Data were analyzed employing SPSS version 26, using Pearson correlations, independent and paired samples t-tests, and linear regression analysis.

3.1. Reliability of instruments

The internal consistency of the instruments was analyzed utilizing Cronbach's alpha prior to hypothesis testing. As presented in Table 1, both scales exhibit reliability coefficients within an acceptable to excellent range, surpassing the traditional threshold ($\alpha > 0.70$).

Table 1. Reliability Statistics for Research Scales.

Scale	No. of Items	Cronbach's α	Interpretation
TPACK	20	0.715	Acceptable
Cooperative Readiness	15	0.794	Appropriate

Note. $\alpha \geq 0.70$ is considered acceptable (Nunnally, 1978).

3.2. Differences in TPACK by Learning Environment

The first research question addressed whether TPACK levels varied significantly between online and face-to-face learning milieus. An independent samples t-test was implemented after confirming the assumption of normality through Shapiro-Wilk tests (Online: $W = 0.921$, $p = 0.128$; Face-to-Face: $W = 0.956$, $p = 0.392$). Descriptive statistics (Table 2) revealed a higher mean TPACK score for participants in online courses ($M = 125.07$, $SD = 5.80$) compared to those in face-to-face ones ($M = 101.38$, $SD = 5.25$).

As shown in Table 2, a significant difference is observed [$t(98) = 18.42$, $p < 0.001$]. The large mean difference ($MD = 23.69$) and the 95% confidence interval (CI) [21.82, 25.56] (excluding zero) indicate that pre-service teachers within online settings reported significantly higher TPACK levels, resulting in rejecting the first null hypothesis.

Table 2. Independent Samples t-test Comparing TPACK Scores by Course Modality.

Group	n	M	SD	t	df	p	Mean Difference	[95% CI]
Online	50	1250.07	5.80	18.42	98	< 0.001	23.69	[210.82, 25.56]
Face-to-Face	50	1010.38	5.25					

Note. CI = Confidence Interval. Levene's test for equality of variances was not significant ($F = 2.97$, $p = 0.090$), confirming the use of the equal variances assumed estimate.

3.3. Effect of TPACK on Cooperative Readiness

The second research question assessed the effect of TPACK on teachers' cooperative readiness. A paired samples t-test was conducted to compare scores under TPACK and non-TPACK frameworks (Table 3). The results revealed a significant increase in cooperative readiness scores under the TPACK framework ($M = 17.07$, $SD = 2.37$) compared to the non-TPACK condition ($M = 12.38$, $SD = 1.94$). The difference was statistically significant [$t(99) = 12.85$, $p < 0.001$]. The mean increase in cooperative readiness scores was 4.69 with a 95% CI ranging from 3.91-5.47 (Table 3), resulting in rejecting the second null hypothesis.

Table 3. Paired Samples t-test for the Effect of Framework on Cooperative Readiness.

	n	M	SD	t	df	p	Mean Difference	[95% CI]
TPACK	100	17.07	2.37	12.85	99	< 0.001	4.69	[3.91, 5.47]
Non-TPACK	100	12.38	1.94					

Note: CI = Confidence Interval.

3.4. Cooperative Readiness as a Predictor of TPACK Implementation

Evaluating the potential of cooperative readiness to predict the successful implementation of TPACK was recognized as the objective. A simple linear regression was statistically significant [$F(1, 98) = 127.25$, $p < 0.001$, $R^2 = 0.565$], representing that cooperative readiness explains 56.5% of the variance in TPACK enactment success.

The regression coefficient (Table 4) for cooperative readiness ($B = 0.87$, $p < 0.001$) shows that the effectiveness of TPACK application rises by 0.87 units for every one-unit increase in cooperative readiness, resulting in rejecting the null hypothesis.

Table 4. Linear Regression Analysis Summary for Predicting TPACK Implementation.

Predictor	B	SE	β	t	p
(Constant)	30.04	4.12		7.29	< 0.001
Cooperative Readiness	0.87	0.08	0.75	11.28	< 0.001

Note. Dependent Variable: Implementation of TPACK. $R^2 = 0.565$, Adjusted $R^2 = 0.560$.

Based on the results, cooperative readiness appeared as a strong positive predictor of effective TPACK implementation, accounting for more than 56% of its variance. The results highlight a strong, reciprocal relationship between TK, PK, and cooperative skills, proposing that promoting collaboration contributes to the effective implementation of technology in teaching. However, these findings should be interpreted with caution given the convenience sampling approach and the self-reported nature of the measures, which may limit generalizability to broader pre-service teacher populations.

3.5. Qualitative Results

To complement and contextualize the statistical patterns identified above, the qualitative phase employed thematic analysis on data from semi-structured interviews with 15 participants to examine the causal mechanisms and contextual factors driving these correlations. Participants in the qualitative subsample ($n = 15$) were purposively selected to represent maximum variation: 8 female and 7 male pre-service teachers, aged 24–31 ($M = 26.1$, $SD = 2.4$), drawn proportionally from all three teacher training centers. Each had completed at least one supervised teaching practicum, ensuring sufficient classroom exposure to reflect meaningfully on technology integration challenges.

The analysis yielded three primary themes: collaboration as a catalyst for overcoming technological anxiety, dialogic construction of integrative knowledge, and peer support as a bridge from theory to constrained practice, which reveal the lived experiences of the pre-service teachers.

Theme 1: Collaboration as a Catalyst for Overcoming Technological Anxiety

The role of collaborative environments in alleviating feelings of anxiety, self-doubt, and failure associated with technology incorporation was among the main themes emerging from the interviews. Participants expressed early apprehension while incorporating digital instruments into lesson plans due to concerns about the potential for technical failure or instructional misapplication.

Within collaborative environments including group practicum projects and peer-teaching sessions, such individual anxiety was transformed into a mutual problem-solving effort. Participants recognized that being part of a collective endeavor nurtured a sense of psychological safety, boosting experimentation and risk-taking which is considered discouraging in isolation.

- Category 1.1: Mutual Vulnerability and Risk-Taking. The interviews discovered that recognizing mutual insecurities was regarded as a critical first step toward fostering confidence.

> «I wanted to conduct a quiz game online in my first microteaching. I feared potential malfunctions of the instrument or students' lack of comprehension. However, I talked with my group, recognizing that all of the members feared similarly. We aimed to practice collectively. One person played the teacher, and the others asked tricky questions. Performing the task in actual classrooms felt less intimidating after experiencing collective failure during practice sessions.» Excerpt 1.1 (Participant 7, female, high TPACK/low cooperative readiness):

The above-mentioned category highlights that cooperative readiness creates a buffer against the fear of failure, supporting pre-service teachers to move from a state of avoidance to one of active experimentation, which is considered a crucial precursor to developing TK and TPK.

Theme 2: Dialogic Construction of Integrative Knowledge (TPACK)

Based on the data, the complex, integrative knowledge needed by the TPACK framework is constructed through conversation and mutual reflection with peers. Participants claimed that their deepest understanding of integrating technology, instruction, and content appeared from discussions requiring articulation, defense, and improvement of their ideas.

- Category 2.1: Moving from «What» to «Why»: Negotiating Instructional Rationale. Collaboration necessitated justification of pedagogical appropriateness for specific content and learners, even if individuals recognized the proper instrument.

> «I proposed applying a vocabulary app for our lesson on academic words. My teammate asked me the reason for selecting that app, questioning its comparative advantage over traditional flashcards for achieving the intended objective. I thought deeply, realizing that the key factor was the spaced repetition algorithm which presented a better method to learn the words. That level of thinking did not emerge by independent reflection.» Excerpt 2.1 (Participant 3, female).

The above-mentioned process of negotiation and justification forced pre-service teachers to make their tacit knowledge explicit, solidifying their own understanding about the interconnected TPACK domains.

Theme 3: Peer Support as a Bridge from Theory to Constrained Practice

The role of collaboration in adapting idealized TK to the realities of resource-constrained educational environments was among the salient themes within the Iranian context. Participants reported that their training often presented instruments and concepts hypothesized to be universally available, leading to frustration when they entered practicum schools with poor internet, limited devices, or skeptical supervising teachers. Cooperative groups became incubators for innovation and adaptation, where pre-service teachers pooled their creativity to develop context-specific solutions.

- Category 3.1: Generating Low-Tech/No-Tech Workarounds. The groups confronting infrastructural restrictions mutually brainstormed effective strategies which associated with TPACK principles free from high-end technology.

> «Our assignment involved designing a blended learning activity, while our practicum school possessed only a single computer lab, which was booked weeks in advance. Thus, we developed a 'low-tech blend' and implemented WhatsApp groups on students' personal phones for exchanging audio recordings and text-based discussions outside of class. We utilized the face-to-face time for cooperative role-plays. We maintained a blended learning approach using technology, while the instrument applied was specifically adapted to work in our setting.» Excerpt 3.1 (Participant 5, female).

The aforementioned theme underlines that cooperative readiness focuses on developing the collective resilience and ingenuity to enact TPACK within specific, and often challenging, real-world settings rather than emphasizing the use of technology in ideal conditions.

3.6. Integration of Quantitative and Qualitative Findings

The quantitative and qualitative strands converge to illuminate not only that cooperative readiness predicts TPACK development (R^2 = 0.565), but also how this relationship operates in practice. Statistically significant correlations are explained qualitatively through three interlocking mechanisms: (1) the affective buffering of technological anxiety through shared vulnerability, (2) the cognitive deepening of integrative reasoning through dialogic negotiation, and (3) the pragmatic adaptation of theoretical knowledge to resource-constrained classrooms through collective problem-solving. This meta-inference suggests that cooperative readiness functions less as a standalone predictor and more as a socially embedded catalyst that activates and sustains TPACK development across emotional, cognitive, and practical dimensions.

4. Discussion

This mixed-methods explanatory sequential study explored the role of cooperative readiness in improving the TPACK of Iranian pre-service EFL teachers. The quantitative results indicated a critical predictive relationship, representing that cooperative readiness is recognized as a considerable element of pre-service teachers' ability to successfully utilize TPACK. This was complemented and explained by the qualitative data, which offered rich, experiential confirmation regarding the function of collaborative practices as a mechanism for increasing the complex, integrative knowledge needed for efficient technology incorporation. The results revealed that nurturing cooperative readiness may be vital for training teachers to explore the challenges of technology-rich, yet often resource-restricted, EFL classrooms.

The role of cooperative readiness as a strong predictor of successful TPACK enactment provides critical empirical evidence for a construct which has been theoretically proposed, yet underexplored, mainly in EFL contexts (Belda-Medina & Calvo-Ferrer, 2022; Ouyang et al., 2021). However, it is important to acknowledge that the observed relationship, while statistically robust, may reflect context-specific dynamics of Iranian teacher education rather than universal patterns. Alternative interpretations—such as the possibility that higher TPACK scores among online learners reflect selection bias rather than causal influence of modality—warrant consideration in future research.

The qualitative results were instrumental in clarifying the mechanisms behind the aforementioned statistical correlations. The development of the theme 'Collaboration as a Catalyst for Overcoming Technological Anxiety' provides a vital affective explanation. The interviews discovered that the fear of technical failure or instructional misapplication is regarded as a substantial barrier to technology incorporation, a concern aggravated in environments such as Iran where infrastructure can be unreliable and traditional methods remain predominant (Abbasi Kasani et al., 2020; Johari, 2002; Karbalaei, 2025). Cooperative milieus alleviated this by transforming individual anxiety into a mutual, collective problem-solving attempt, which aligns with the concept of psychological safety within communities of practice, where shared vulnerability boosts risk-taking and experimentation, behaviors essential to increasing TK and TPK (Maor, 2017). As participants highlighted, a technical problem becomes a 'group problem to solve' rather than a 'personal failure,' resulting in lowering the emotional filter which often hinders innovation.

Furthermore, the theme 'The Dialogic Construction of Integrative Knowledge' presents a cognitive framework elucidating the role of cooperation in developing TPACK. Based on the data, the deep, integrative understanding at the core of TPACK is collaboratively constructed through conversation, negotiation, and the necessity to articulate and defend teaching rationales, resulting in encouraging pre-service teachers to transcend instrument selection and develop a nuanced comprehension about the pedagogical rationale and operational applicability for specific content and learners. This result fosters the socio-constructivist foundations of TPACK and collaborative learning theory (Mishra & Koehler, 2006; Ouyang et al., 2021). It extends Shulman's (1986) original concept of instructional reasoning, fostering CK for instruction, into the digital realm, proposing that such transformation is attained through social interaction and reflective discourse with peers. Recent work by Yildiz

Durak et al. (2023) and Kim (2025) similarly emphasizes that TPACK development is fundamentally dialogic, suggesting that our findings contribute to an emerging consensus about the social nature of technological-pedagogical knowledge construction.

Finally, the theme 'Peer Support as a Bridge from Theory to Constrained Practice' investigates a critical contextual challenge in Iran and related settings. Teacher education programs often present technological frameworks based on the assumptions of ideal access and conditions, generating a theory-practice gap which can create frustration and cynicism (Ottenbreit-Leftwich et al., 2012). The qualitative data discovered that collaborative groups became vital incubators for flexibility and resilience. Collaboration helped pre-service teachers foster their creativity to nurture low-tech workarounds and context-specific strategies, including the implementation of WhatsApp to make a 'low-tech blend', which confirms that cooperative readiness is about increasing the collective capacity to implement TPACK principles pragmatically within local limitations, not about applying innovative technology in ideal contexts. Additionally, collaboration offered a rehearsal space for developing the discourse required to advocate for technology use with more traditional mentors, a vital skill for promoting change in established educational cultures.

4.1. Practical Implications

The findings suggest three actionable implications for teacher education programs in resource-constrained contexts: (1) Integrate collaborative reflection systematically into technology courses rather than treating collaboration as an ancillary skill; (2) Design practicum experiences that explicitly pair pre-service teachers for joint problem-solving around technology integration challenges; and (3) Equip teacher educators with facilitation strategies to nurture psychological safety and dialogic reasoning within collaborative groups. These recommendations align with recent calls for socially embedded approaches to teacher preparation (Chai, 2018; Lim et al., 2011) and offer a pragmatic pathway for bridging the theory-practice gap in technology-rich EFL instruction.

The present study emphasized that the development of TPACK and cooperative readiness is recognized as a synergistic and bidirectional process. As for pre-service EFL teachers in Iran, collaboration functions as a powerful engine which drives TPACK development on numerous fronts, decreases emotional barriers, catalyzes deep cognitive processing through conversation, and allows practical adaptation to real-world limitations. Thus, teacher preparation programs should transcend just offering detached courses in educational technology. Rather, they should deliberately design learning experiences which link TK, PK, and CK with constant opportunities for collaborative practice, reflection, and problem-solving (Lim et al., 2011; Kim, 2025). By fostering cooperative readiness, teacher educators can better prepare pre-service teachers to become reflective, flexible, and collaborative practitioners adept in navigating the complexities of modern EFL classrooms.

5. Conclusion

This study examined the intricate relationship between cooperative readiness and the development of TPACK among Iranian pre-service EFL teachers. The mixed-methods approach offered a complete understanding, indicating that cooperative readiness functions not merely as a complementary skill but as a vital catalyst which predicts and fosters the development of integrative TPACK. The quantitative results identified a strong statistical link, suggesting that a pre-service teacher's preparedness to collaborate serves as a significant contextual factor in their ability to efficiently apply technology in instruction. Further, the qualitative insights illuminated the lived experiences behind this correlation, specifying the function of collaboration as a mechanism to overcome anxiety, construct knowledge through conversation, and bridge the gap between theoretical training and limited practical realities. Unlike prior studies that treat collaboration as an ancillary classroom strategy, this research positions cooperative readiness as a foundational psychosocial precondition that actively shapes how pre-service teachers synthesize technological, pedagogical, and content knowledge.

The present study holds significant implications for teacher education programs, mainly in settings similar to Iran where infrastructural and cultural restrictions can hinder technology integration. The results revealed that the traditional model of teaching technology skills in isolation lacks efficacy. Teacher education should be re-envisioned to systematically and deliberately embed collaborative experiences throughout the curriculum. This process includes planning teacher training which mirrors the collaborative and technologically complex settings in which future educators will work. Practicum experiences, micro-teaching sessions, and curriculum design projects should be planned as collaborative endeavors, pushing pre-service teachers to negotiate, defend, and improve their integrative knowledge with peers. To operationalize this shift, teacher educators should be trained to facilitate dialogic reflection and design scaffolded group tasks that explicitly target TPACK domains, rather than assuming collaboration will emerge organically.

The present study advances discourse on teacher preparation for the digital age, emphasizing that the path to effective technology incorporation hinges on social processes. The journey from possessing isolated TK to understanding their dynamic incorporation is best navigated collectively. Therefore, promoting cooperative readiness plays a vital role in this regard. By learning to collaborate, pre-service teachers can modify, innovate, and transform their classrooms into effective, engaging, and responsive learning environments for the 21st century.

While this study offers valuable insights, several limitations warrant acknowledgment. First, the convenience sampling strategy, though pragmatic, limits statistical generalizability; future research should employ stratified random sampling across diverse Iranian regions to enhance external validity. Second, reliance on self-reported TPACK measures may introduce social desirability bias; subsequent studies could triangulate survey data with classroom observations or artifact analysis. Third, the cross-sectional design precludes causal inference; longitudinal investigations tracking cooperative readiness and TPACK development across pre-service and early in-service phases would strengthen theoretical claims. Finally, while the Iranian context provides critical insights for resource-constrained settings, comparative studies across cultural and infrastructural contexts could elucidate boundary conditions for the cooperative readiness–TPACK relationship. Addressing these limitations would advance both methodological rigor and theoretical generalizability in this emerging area of inquiry.

6. Authors' Contributions

All authors contributed to the study's conception and design. Hamid Heidari led the literature review, developed the theoretical framework, designed and implemented the mixed-methods instruments, conducted quantitative and qualitative data analysis, and wrote the first draft of the manuscript.

Alireza Karbalaei contributed to instrument validation, assisted in data collection and coding, performed reliability checks on qualitative analysis, and provided critical revisions to the manuscript. He also supervised the overall research project, provided methodological and theoretical guidance, contributed to interpretation of findings, and edited multiple drafts for conceptual clarity and academic rigor.

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ARTICLE / ARTÍCULO

Generative Artificial Intelligence, Perceived Effort, and Critical Thinking: Evidence from an Experimental Study with ChatGPT in Higher Education

Inteligencia artificial generativa, esfuerzo percibido y pensamiento crítico: evidencias de un estudio experimental con ChatGPT en Educación Superior

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Abstract: The emergence of Artificial Intelligence (AI) has had a profound impact on diverse sectors, including education. While the integration of technology into classrooms has been a constant for decades, both educators and students face new challenges due to the advent of NLP systems. Educators deal with analyzing and evaluating the originality of an essay. With the application of AI, students can answer theoretical questions and solve complex exercises, but grapple with the challenge of collaborating and engaging with a tool that relies on natural language instructions but can also provide outright incorrect responses. Our study aims to assess the effectiveness of ChatGPT in solving a case study with quantitative questions. We seek to compare the performance of students who use the tool with those who do not, from formulating instructions to validating or assessing the results. The data collected through pre-, and post-test questionnaires reveal consistently better results in students who did not use ChatGPT. However, the expectation of result accuracy and confidence in the outcomes obtained are similar in both groups. We suggest this to be interpreted as an effect that we call "Blind to Fraud" describing the situation in which students appear unaware of the likelihood of inaccuracy when using an AI-based NLP tool, which shows overconfidence in the results obtained. This can significantly impact learning outcomes and should be counterbalanced through critical thinking skills in education.

Keywords: Artificial Intelligence, ChatGPT, Illusion of Explanatory Depth, Critical Thinking, Higher Education.

Resumen: La aparición de la Inteligencia Artificial (IA) ha tenido un profundo impacto en diversos sectores, incluida la educación. Aunque la integración de la tecnología en las aulas ha sido una constante durante décadas, tanto el profesorado como el alumnado se enfrentan a nuevos desafíos debido a la irrupción de los sistemas de procesamiento del lenguaje natural (PLN). El profesorado debe afrontar el análisis y la evaluación de la originalidad de los ensayos. Mediante el uso de la IA, el alumnado puede responder preguntas teóricas y resolver ejercicios complejos, pero se enfrenta al desafío de colaborar e interactuar con una herramienta que se basa en instrucciones expresadas en lenguaje natural, pero que también puede proporcionar respuestas completamente incorrectas. Nuestro estudio tiene como objetivo evaluar la eficacia de ChatGPT para resolver un estudio de caso con preguntas cuantitativas. Pretendemos comparar el rendimiento del alumnado que utiliza la herramienta con el de quienes no la emplean, desde la formulación de instrucciones hasta la validación o evaluación de los resultados. Los datos recopilados mediante cuestionarios administrados antes y después de la prueba muestran resultados sistemáticamente mejores entre el alumnado que no utilizó ChatGPT. Sin embargo, las expectativas sobre la exactitud de los resultados y la confianza en los resultados obtenidos son similares en ambos grupos. Proponemos interpretar este fenómeno como un efecto que denominamos «ceguera ante el fraude», que describe una situación en la que el alumnado parece no ser consciente de la probabilidad de obtener resultados inexactos al utilizar una herramienta de PLN basada en IA, lo que se manifiesta en una confianza excesiva en los resultados obtenidos. Este fenómeno puede afectar significativamente a los resultados de aprendizaje y debería contrarrestarse mediante el desarrollo de habilidades de pensamiento crítico en la educación.

Palabras-clave: Inteligencia Artificial, ChatGPT, Ilusión de capacidad explicativa, Pensamiento crítico, Educación Superior.

1. Introduction

The widespread access to Natural Language Processing (NLP) models based on Artificial Intelligence (AI) has made a significant impact across various sectors (Odden et al., 2021), ranging from economics, business, and medicine to education. NLP models rapidly revolutionize teaching and learning by enabling personalized learning and on-demand support. Universities have long pursued pedagogical innovations, integrating technology to strengthen student-teacher relationships and equip students with real-world problem-solving skills. This paradigm includes technology-based learning, social networks, and global interactivity (Harasim (2000), Raja and Nagasubramani (2018)). Therefore, not only are innovative teaching techniques necessary but also their integration into the learning process.

Evidently, NLP models are here to stay, if not forever. Students are familiar with them, use them, and know their advantages. Evidence from a large-scale global study involving over 23,000 students across 109 countries confirms that, while students value ChatGPT for simplifying complex information and summarizing content, they find it considerably less reliable for supporting classroom learning (Ravšelj et al., 2025). Recent literature highlights that NLP-based AI systems such as ChatGPT simultaneously present substantial opportunities and significant pedagogical risks for higher education institutions (Fuchs, 2023). A systematic review of ChatGPT's limitations across multiple fields identifies accuracy and reliability concerns, constraints on critical thinking and problem-solving, and ethical and privacy issues as the most prominent challenges associated with its use (Sok & Heng, 2024). These findings are particularly relevant in educational contexts, where students' inability to detect or verify incorrect outputs may have direct consequences on learning outcomes. Academic institutions can either attempt to prevent their use, which requires significant efforts focused on plagiarism. Alternatively, academic institutions and educators can accept their use and adapt teaching methodologies to show the benefits of AI without students adopting the passive role of copying and pasting responses. Among other tasks, educators must prepare and adapt their classes and activities for AI use so that AI becomes a complement and collaborator rather than a substitute for students' (and teachers') work. This approach can enhance learning by involving students, as they need to acquire new skills, such as effectively expressing questions, objectives, and instructions in natural language, as well as validating or evaluating the obtained responses.

Among the alternatives available, ChatGPT is the most popular NLP model. Developed by OpenAI, it utilizes a vast dataset to generate text responses to user queries, feedback, and prompts (Gilson et al., 2023). Therefore, considering the trend in the university towards the use of ICT (Information and Communication Technology) in the classroom, this study empirically analyzes whether the use of ChatGPT can, as suggested by the literature, complement the learning process, and enhance students' knowledge.

The study was conducted using an experimental methodology with international and Spanish students. The research aims to assess the performance, effort, and confidence of students using ChatGPT to solve a quantitative case study. Beyond its capacity for data processing, we operated under the assumption that ChatGPT could offer strategic value to solving the case study. Based on our initial assumptions regarding its utility, we highlighted these specific tasks: clear identification of business problems; identification of key data to solve a problem; identification of the necessary analytical techniques to solve a problem using the provided data; calculation and numerical results obtained by applying the necessary techniques; analysis of the validity of the obtained data; relevance of the data in relation to the problem; contextualized interpretation of the results; providing appropriate solutions by by providing informed insights.

The results are evaluated and discussed considering the following presumptions, which are based on Lo (2023), our experience, and the literature on students' competency outcomes in higher education (Nikolaos et al., 2019; Liesa-Orus et al., 2020). They are presented in Table 1.

Table 1. Presumptions of the research establish that «the group that uses ChatGPT vs non ChatGPT users…»

Id.	Presumptions
P.a	Achieves a higher grade in the case study.
P.b	Performs better in identifying company needs and goals.
P.c	Has a greater level of accuracy while using the appropriate technique for knowledge needs.
P.d	Has a lower level of accuracy while calculating the outcomes.
P.e	Has a greater level of accuracy when analysing statistical validity.
P.f	Has a higher accuracy in interpreting and suggesting solutions based on the data gathered.
P.g	Has a greater rate of response and consequently is able to answer more questions.
P.h	Has higher grade expectations.
P.i	Perceives a lower effort invested to solve the case study.
P.j	Would exhibit lower confidence due to their inability to oversee or verify the results.

Given the appeal of digital tools to young people (Irfan et al., 2023), the study explores students' perceptions of utilizing the tool and the consequences of its use on learning as well.

The study's findings can be useful for educational institutions and educators since they quantify the benefits of using AI-based NLP vs not using it.

It also investigates students' perspectives after completing a task utilizing this technology. Furthermore, the appropriate use of ChatGPT also implies a set of skills that must be developed during the university period, particularly two: the ability to ask in an orderly and conducive manner to a result (identification of task objectives), and the ability to interpret the results obtained: coherence, problem-solving ability, and reliability, among others.

In this context, we introduce the concept of "blindness to fraud" to describe the situation in which students appear unaware of the likelihood of inaccuracy when using an AI-based NLP tool and hence lack awareness of their genuine degree of understanding in the field. This dynamic could facilitate the replication of this study in multiple subjects with different core abilities involved, as well as giving a framework for contemplation on how to design tasks that can be performed in 'partnership' with AI.

Finally, teachers and institutions can investigate what complementary learning is required (communication with AI, learning to prompting, computational thinking, and skills to verify the results obtained) for the effective integration of AI into the classroom, i.e., to accelerate and personalize learning for university students, particularly in avoiding the "Blind to Fraud" effect. The article continues with the review of the literature, analyzes the methodology, followed by the results and conclusions of the study.

1.1. Review of Literature

The application of digital tools in education has broadened since Vygotsky and Cole's (1978) Activity Theories. Individuals, according to their viewpoint, exist inside a sociocultural framework and constantly shape their surroundings, interacting and developing new cultural mechanisms. According to Leontiev (1978), interaction is more than just a reaction; it causes internal changes that promote one's own development. Furthermore, Westin et al. (2015) investigated the role of ICT in their interactions with students and teachers, and how this improves interactivity and learning.

However, not all examples of technology adoption in the classroom provide favorable results (Moss et al., 2007), as educational outcomes largely depend on teachers' pedagogical approaches and the ways technology is integrated into learning processes. In this context, the emergence of new digital technologies does not diminish the role of educators; rather, it transforms their responsibilities toward guiding students in the effective and critical use of technological tools (Rawlins & Kehrwald, 2010). Teachers must therefore adapt their methodologies to ensure that AI-based tools maximize not only access to content, but also the development of meaningful learning processes and analytical skills.

From this perspective, AI holds substantial promise for improving learning, teaching, and support practices in higher education (Smith, 2022). For example, AI-powered chatbots can provide immediate support to students by enhancing their learning experience, motivation, and engagement (O'Connor and McAndrew, 2021). Educators face a dual challenge: on the one hand, teachers must adapt their method to AI (Firat, 2023), and on the other, they must develop evaluation methods that enhance the detection of assignments whose authorship can be substantially attributable to AI. Simultaneously, students confront the problem of 'collaborating' with AI to improve their abilities, which necessitates skills in natural language querying and evaluating responses not only for correctness but also for relevance to the inquiry's goals.

Since ChatGPT's public release, scholars have examined its implications for higher education from multiple perspectives, including opportunities for productivity and learning, risks for assessment and academic integrity, ethical concerns, and disciplinary applications. Examples of numerous publications on this subject include Arif et al. (2023); Farrokhnia et al. (2023); Fauzi et al. (2023); Gilson et al. (2023); Mhlanga (2023); Rospigliosi (2023); Rudolph et al. (2023); Thurzo et al. (2023); Tlili et al. (2023). Tajik and Tajik (2023) add a further layer, categorizing the impacts of ChatGPT, or the deployment of other NLP-based AI models, into three categories: students, teachers, and the educational institution itself.

According to recent studies, the employment of AI in higher education can result in significant improvements across a variety of areas. AI-based educational tools have been associated with enhanced learner engagement, personalized learning experiences, and improved academic support (Yang et al., 2020; Tate et al., 2023). In particular, Nisar and Aslam (2023) found that ChatGPT can function as an effective self-learning and rapid-reference tool for students studying pharmacology, highlighting its potential to support autonomous learning processes. Similarly, Firat (2023) argues that ChatGPT may transform self-directed and open education environments by encouraging students to take greater responsibility for their own learning outcomes.

The study emphasizes students' need to master formulating relevant questions, engaging constructively with the NLP tool, and evaluating its responses. This involves overcoming challenges in framing queries, synthesizing information, and validating data to solve complex case studies effectively.

Another key difficulty that students may face is the possibility of being overly reliant on technology, which can undermine the development of critical thinking abilities such as the capacity to evaluate source quality and dependability, make informed decisions, and produce new ideas. Students may fall victim to what Rozenblit and Keil (2002) refer to as «the illusion of explanatory depth», in which they assume they have a thorough understanding of a subject despite having only superficial knowledge (Chromik, 2021). It is worth emphasizing that, to the best of our knowledge, this effect has been most prominently found in tasks demanding explanatory knowledge and complicated causal patterns, but not in other activities such as following a method or providing factual descriptions. Chromik's (2021) article empirically establishes the reality of this impact.

According to Lo (2023), ChatGPT performs remarkably well in economics, satisfactorily in programming, and disappointingly in fields such as mathematics. Regardless of the areas where it demonstrates higher proficiency, this performance variation is exciting for a thorough case study, as presented to students in the current experiment, where performance may be examined in a variety of areas, including statement interpretation, computation, and proposal writing, all based on the case study findings.

2. Methodology

This paper describes an exploratory experimental investigation in which results were examined using inferential statistics.

2.1. The experiment

A total of 30 students were divided into two groups with the goal of resolving the same case study: 1) a control group (50% of students) that will use the statistical software (SPSS) learned during the subject, and 2) another group that will exclusively use ChatGPT. All students had already completed the entire curriculum (Market Research) and had experience working with similar case studies using SPSS.

The task required students to solve a case study consisting of thirteen questions with the goal of assessing the three distinct skill categories that they ought to have mastered at the end of the course. For the competency rubric, the questions are grouped according to the skill category involved and the competency area, according to the following scheme shown in Table 2.

Table 2. The case study examined three skill categories, raised thirteen implicit questions about the skills, and evaluated three competency groups.

Categories of skills evaluated in the study		**Questions implied in every skill**	**Groups of competencies assessed through the questions**
Category #1: Recognition of business problems, needs and goals that can be solved through quantitative market research		1	Critical reading, understanding of a business context
Category #2: Identification and application of statistical analysis techniques to solve	2.1. Statistical Techniques to be applied	4, 7 & 10	Statistical techniques, calculation, and validity analysis

problems. Divided into 3 components:	2.2. Results obtained in the analysis	2, 5, 8 & 11	
	2.3. Validity of the results	6, 9 & 12	
Category #3: Interpretation of outcomes considering the problems and needs of the business represented in the case study		3 & 13	Selection and interpretation of outcomes, as well as proposed business solutions

2.2. Construct and instruments' validation

For this exploratory research, a convenience sampling method was employed due to the accessibility of subjects within the academic environment. To strengthen internal validity, a split-classroom design was used to conduct a small-scale Randomized Controlled Trial (RCT).

Participants from the same class were randomly assigned to either the Chat GPT or SPSS group. This approach is methodologically more robust than using intact groups as it eliminates selection bias. Furthermore, since all students belong to the same section, they share identical prior training, which minimizes external variables and allows for a more precise comparative evaluation of the results in a natural classroom setting (ecological validity). This sampling approach was adapted from Verenikina's framework (2010) to the context of a public university in Madrid.

Since this research constitutes an exploratory experiment, our initial analysis primarily relies on inferential statistics, which includes T-Test for independent groups, and the effect sizes attributable to the use of ChatGPT. Occasionally, when the effect size is small or to isolate specific variables, correlations are applied.

Along with the 13-question case study, every student was asked to complete two questionnaires (Tables 3 and 4). The first questionnaire was delivered before accessing the case study and gathers sociodemographic (questions 1-3) and academic data (questions 4-11). The second questionnaire gathers perceptions about the task (questions 12-17), after completing the case study but before knowing the results of the exercises. The questionnaire development process was conducted under the supervision of one of the co-authors of the research, a pedagogue in case study methodology, and reviewed by three experts.

Table 3. First questionnaire (before the task): academic and character variables*

Item	Questions

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1	Age
2	Country
3	Educational background
4	What´s your perception about your current skills on using AI?
5	What is approximately your GPA (average of your previous marks) in your university degree)?
6	What is the average score you obtained in previous assignments in Market Research II?
7	According to your own estimation, how many sessions of Market Research II, expressed as a percentage, did you attend during the semester? (Consider 1 as less than 10%, 2 as 20%, and so on until 10 which represents 100%)
8	How strong do you feel with your current knowledge in Market Research II?
9	How strong do you feel is your current knowledge concerning the interpretation of client's business needs and business goals?
10	How strong do you feel is your current knowledge concerning the different statistical techniques applied to analyse data in market research?
11	How strong do you feel is your current knowledge concerning the interpretation of results to provide suggestions or solutions based on data analysis results?

* Scale 1-10

The second questionnaire (Table 4) includes students' estimation of the outcomes achieved after completing the activity. Only for students who use ChatGPT does it incorporate additional questions, the number 13 and 17.

Table 4. Second questionnaire (after task): students' estimation of the outcomes achieved*

Item	Questions
12	What is the mark you consider you obtained in the case study?
13	How easy was to find the way (language, structure, procedures...) to cooperate with ChatGPT?
14	Regarding the effort required to solve the case study… how easy was it?
15	How confident do you feel about your answers?
16	Consider that this would have been a professional environment and the case study a real case of a real client. How confident would you feel about presenting these results to a client?
17	If you had to distribute the mark in the case study between the AI and you, what would be your share?

* Scale 1-10

The fact that we compare data given by students makes it easier to compare the results produced using the two alternative data gathering approaches. On the one hand, we inquire using numerical rating scales (ranging from 1 to 10) that correspond to both questions about their perceived knowledge of the subject as a whole and their level of competence in each of the critical skills involved in solving the case study (questions 1 to 11); Cronbach's Alpha yields a result of 0.885, indicating an excellent level of reliability for the construct.

In contrast, Likert-type scales were used to assess the level of agreement with a proposition. This scale is appropriate for establishing comparisons when alternatives are difficult to assess because they are dependent on individuals' proclaimed perceptions. This type of scale is used to assess students' confidence in the results obtained, on a scale of 1 to 10, with 1 indicating "No confidence at all" and 10 indicating "Total confidence" (Questions 12 to 17). Cronbach's Alpha is applied again. The result is outstanding, demonstrating a high level of construct reliability (0.943).

Finally, when we use Cronbach's Alpha to test the degree of the overall construct reliability, this time with all the questions and scales employed. We get a result of 0.800, indicating that the scales and the construct itself have statistical validity.

3. Results

Once the suitability of the measurement construct was confirmed, our primary goal prior to analysis was to evaluate the groups' comparability. There is no important difference in the information collected from questions 1, 2 and 3, since these are students aged 20-21, a high percentage from Europe, and with similar previous studies.

Regarding questions 4 to 11 (Table 3), the results obtained in each group (Table 5) are also very similar. The result has a high statistical significance ($p < 0.05$), which means that it is statistically legitimate.

Table 5. Information gathered for the two student groups from the initial questionnaire. Questions 4-11*

Questions #	ChatGPT Users	Non ChatGPT Users
4: Current skills using AI	7.33	7.14
5: Current GPA	7.27	7.15
6: Previous marks in Market Research II	6.87	7.14
7: Attendance during the semester	7.13	7.07
8: Confidence in knowledge of Market Research II	5.73	5.00
9: Confidence in business needs and goals	6.00	5.64
10: Confidence in statistical techniques	5.20	4.79
11: Confidence in interpretation of results and solutions	5.80	5.14

* Scale 1-10

Because there are no discernible differences between the two student groups, we proceeded with the analysis..

3.1. Performance in competencies in the subject and performance in the task [Pre-Assumptions P.a) to P.f)]

Following that, we sought to investigate the Presumptions presented in Table 2. The summary can be found in Table 6, where a column has been added that shows the grade obtained in the case study.

Table 6. Actual results and standard deviation on the case study divided into categories* for both groups of students.

Category of skills	ChatGPT Users	StDev (%)	Non ChatGPT Users	StDev (%)
1. Recognition of Business needs and goals	1.72	0.11	3.85	0.08
2.1. Statistical techniques to be applied	3.75	0.05	6.63	0.05
2.2. Results obtained in the analysis	0.66	0.17	5.90	0.06
2.3. Validity of the results	5.00	0.06	5.64	0.06
3.Interpretation of the results	2.17	0.05	5.95	0.04
Grade achieved in the case study	1.72	0.69	4.91	0.61

* Scale 1-10

3.2. Presumption P.a): Grade of the case study

Starting with Presumption P.a), that establishes that "the group that uses ChatGPT achieves a higher grade in the case study", the data unequivocally demonstrate that ChatGPT users performed noticeably worse on average than non-users, while having a relatively high self-perception of competence with AI tools (Table 5). However, the average might conceal a high data dispersion, which was verified by calculating the standard deviation.

The standard deviation is low and very similar in both groups of students (except for the competency of calculating results for the group that used ChatGPT). Therefore, the average can be considered consistent for the analysis. This allows us to reject our assumption P.a), although a further analysis will be conducted to determine the possible cause.

3.3. Presumptions P.b) to P.f): Performance and accuracy.

The effect of the previous mark on the subject.

As the performance difference is so significant, we wanted to rule out any relationship between GPA or current subject grade (Question 5) with the outcome. The correlation result is statistically valid ($p<0.05$) only for the relationship between the Previous Mark in the subject and skill #1. "Identification of Business needs" which shows a positive moderate intensity (+0.435) and the skill #4. "Validity of the results" (+0.431). Therefore, both skills could be explained for the whole group by the influence of the current mark in the subject. The remaining variables have a significance greater than 0.05 and are thus dismissed.

To complete the exploration of these skills, a test of Compared Means for independent samples was conducted since the most plausible explanation was that the use or non-use of ChatGPT could account for these differences. The result obtained is statistically valid (sig. <0.05), but it shows low to moderate effect sizes (Table 7) (in this case, Cohen's D is chosen because the standard deviations were similar).

Table 7. Cohen's D to measure the effect size in skills 2.1, 2.2 and 3.

Skills	**(2.1) Statistical techniques to be applied**	**(2.2) Results obtained**	**(3) Interpretation of results obtained**
Cohen's D (points stimation)	0.28	0.34	0.17

Therefore, the use of ChatGPT cannot be statistically attributed to a greater or lesser demonstration of performance in the skills described. Thus, we could challenge the conclusion of Lo (2023), which qualitatively summarizes perceptions from different studies about ChatGPT's performance in various competency areas. According to our data, the direct influence of ChatGPT usage on the performance in the measured competencies in isolation cannot be attributed because prior subject knowledge has a more significant influence. This allows us to reject, either through a correlation analysis or through the effect size, our assumptions P.b) to P.f) except P.c), because ChatGPT users do not achieve a higher grade in the case study (P.b); do not perform better in identifying company needs and goals (P.d); do not have a greater level of accuracy when analysing statistical validity (P.e) neither have a higher accuracy in interpreting and suggesting solutions based on the data gathered (P.f). Concerning P.c) we can confirm the presumption because ChatGPT users show lower level of accuracy while calculating the outcomes.

It can also be added, in relation to P.a) that when considering the final grade in the case study for both groups of students (and not just the result in each competency), the difference can be explained by the effect size, as in this case, the result of Cohen's D is 2.24. In other words, the final grade in the study significantly depends on the use or non-use of ChatGPT for its resolution. In this case, students who used ChatGPT exhibited significantly lower performance. Therefore, the use of ChatGPT negatively affects the overall case study

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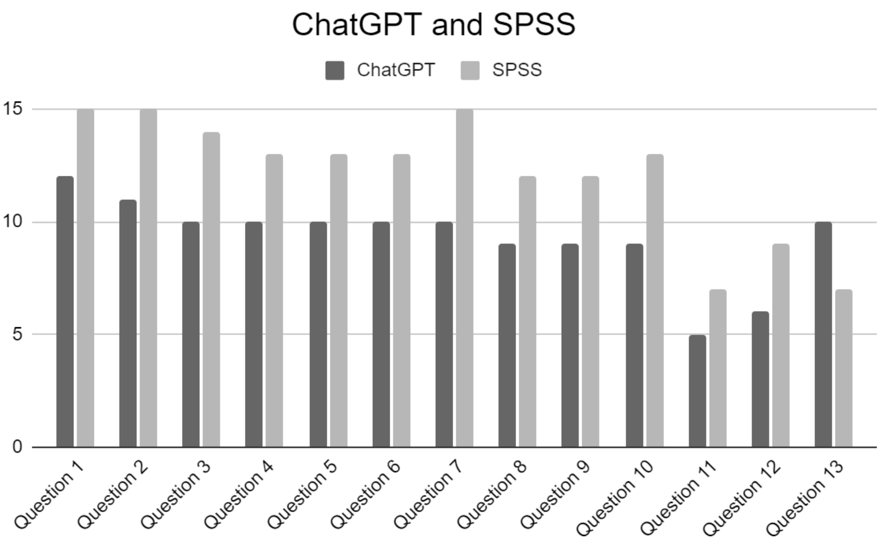
resolution process. Since the final grade depends on the partial grades, and statistical significance for individual competencies showed that the result in every skill was not attributable to the use of ChatGPT, although the result was clearly lower, it is possible to conclude that the focus should not be directed toward different skills, as concluded by Lo (2023) in their review study, but in the main task where the contribution of ChatGPT is decisive and reduce significantly the students' performance.

In short, without detracting from the individual competencies involved, we seek a holistic impact on the very process of developing solutions to complex tasks.

3.4. Presumption P.g): Rate of response

Another noteworthy aspect of performance is the rate of response of both groups of students. Figure 1 provides a summary of the number of responses per question in the case study.

Figure 1. Number of students responding per case study question, using ChatGPT and SPSS (Non ChatGPT users).



In all competencies (see Table 2) except for Category#3: Interpretation of results (question 13) ChatGPT users answered fewer questions, which contradicts our assumption P.g): "The group that uses ChatGPT has a greater rate of response and consequently is able to answer more questions".

It is significant, nonetheless, that 10 out of the 15 students who used ChatGPT answered the last question, but their result was notably lower (2.17/10) compared to only 7 students in the group that did not use ChatGPT, who obtained (5.95/10). They were required to develop a buyer persona using the information from the case study. Students who used ChatGPT provided an answer, although in most cases, it was not based on the case study data or often related to the company's situation. However, students trusted in a well-structured, narrated, and plausible response provided by ChatGPT.

Therefore, the use of ChatGPT did not result in a higher response rate overall, implying greater real ease in completing the case study, so assumption P.g) must be rejected.

3.5. Presumption P.h): Grade expectations

After the resolution of the case study, not only were students graded, but they were also asked about the grade they expected to receive. While students who used ChatGPT expected better grades in the case study compared to those who used SPSS, their actual grades were significantly lower than anticipated. Conversely, students who did not use ChatGPT slightly underestimated their scores. Table 8 illustrates the disparities between estimated and actual grades for both groups.

Table 8. Actual score and estimated score for both groups of students, after the case study resolution.

	Actual	Estimated
ChatGPT Users	1.72	5.00
Non ChatGPT Users	4.91	4.31

When we apply the independent samples T-test to the grade estimation variable, we obtain a Cohen's D value of 2.52, indicating that the use or non-use of ChatGPT clearly influences grade estimation. Hence, although ChatGPT usage impacts academic performance by lowering it, it does raise grade expectations significantly, resulting in a noticeable overestimation of expected grades. This allows us to confirm our assumptions P.h) that establishes that the group that uses ChatGPT has better grade expectations.

According to the data analysis, we can conclude that the use of ChatGPT did not lead to higher performance in task resolution quality, nor in the grades obtained, nor in the number of questions they were able to answer; but surprisingly did so for the performance's expectation. Subsequent sections of this article will explore the potential reasons and implications of this overestimation.

3.6. Presumption P.i): Effort required

Apart from the grade, we were interested in the effort required as ChatGPT should contribute to reducing it. Comparing ChatGPT users and non-user students concerning the perception of effort invested to solve the case study, students using ChatGPT perceived a lower effort (Table 9).

Table 9. Perceived effort to solve the case study for both groups of students.

	ChatGPT Users	Non ChatGPT Users
Effort	5.5	7.15
StDev	3.23	1.67
StDev%	58.69%	23.4%

Given the significantly higher standard deviation among students who used ChatGPT, an analysis was conducted to assess if prior subject knowledge or overall GPA explained this variation. The result of a correlation analysis between both GPA and Subject Mark with the effort required is not statistically significant. Considering that the difference is high and cannot be explained by a confounding variable, we decided to conduct a T-Means test for independent groups.

The effect size measurement using Glass's Delta revealed a statistically significant result, with a large effect size (Glass's Delta = 3.228), indicating that the use of ChatGPT had a substantial impact on perceived differences in effort. The study also examined how the perception of effort influenced the estimation of obtained grades for both groups. The results, which were statistically valid (sig < 0.05), demonstrated a moderate (-0.4) and negative influence.

The negative, moderate, and statistically valid correlation between effort and grade perception implies that when less effort was perceived, students tended to expect higher grades. This may contribute to the greater optimism observed among students who used ChatGPT, as they perceived their effort to be significantly lower.

One potential factor influencing the perceived effort of students who used ChatGPT is the difficulty in using the tool itself, rather than the difficulty of the case study. The study investigated this by asking students to rate the ease of cooperating with ChatGPT on a scale from 0 (Easy) to 10 (Hard). The result was 3.71, indicating a moderate/low level of difficulty in working with the tool. In Figure 2, we show the greater difficulties in a frequency table.

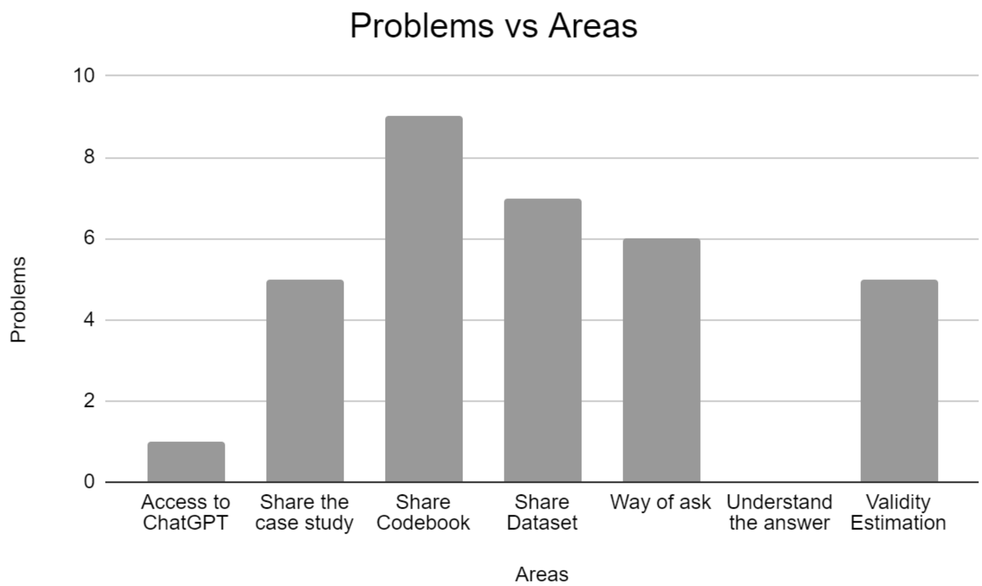


Figure 2. Frequency of problems found when interacting with ChatGPT by different areas.

In terms of effort needed to complete the study, students using ChatGPT had an average of 46.9 interactions with the NLP, almost one interaction per minute, with a high standard deviation of 0.62 Variation Coefficient.

An analysis of the correlation between the effort required to solve the case and the ease of cooperation with the tool shows a highly influential negative correlation (-0.57) between them, indicating that the greater the difficulty in using or cooperating with the AI, the greater the perceived effort. It does not seem risky to assume, therefore, that much of the perceived effort was invested in using the tool. This suggests that the effort dedicated to the case was perceived as very low or that the focus was more on using the tool and less on the case study, with students accepting the answers uncritically once obtained. The fact that no student reported difficulties in understanding the answers clearly confirms this.

Furthermore, as we showed previously, there was a significant difference in the number of interactions needed within students using ChatGPT. To analyze this high standard deviation, a Pearson correlation coefficient was calculated with both GPA and the current grade in the subject. The result showed no significant correlation with GPA, but it was significant with the current grade in the subject, yielding a result of -0.522 (two-tailed significance 0.06). In other words, students who performed better in the subject needed significantly fewer interactions with ChatGPT. Higher subject grades correlate with fewer interactions needed with the NLP tool.

Distribution of workload and marks between the student and AI

Then, we analysed students' credit allocation between themselves and ChatGPT. When asked to distribute marks on a scale from 0 to 10, where 0 implied the AI did all the work, and 10 implied the student did everything with the AI as a simple calculator, the average response was 3.82, indicating that students believed they contributed slightly less than the AI to solve the case (less than 50%).

The study further investigated what influenced this distribution. We considered the ease of cooperation with the AI and found a negative correlation of -0.675 (with statistical significance). Then, the more difficult it was to cooperate with the AI, the less students perceived the AI's contribution. This reinforced the idea that students' perceived effort primarily stemmed from the difficulty of using the NLP tool, rather than the case study itself.

Additionally, there was a moderate negative correlation (-0.593) statistically valid between the grade estimation and the distribution of contribution. In other words, the higher the grade estimation, the less contribution students attributed to the AI.

The study consistently found that:

a) Students' effort depended more on ChatGPT's usability than task difficulty.
b) Contribution distribution was strongly influenced by the ease of cooperating with the AI.
c) Higher self-assessed performance led to reduced attribution of achievement to AI.

3.7. Presumption P.j): Evidence of confidence in the results

Students were informed about using ChatGPT, but when it came to an answer as simple as a mean, 60% gave incorrect answers and 40% skipped basic calculations, neglecting simpler tools like calculators. In contrast, students who did not have access to ChatGPT answered correctly 93.3% of the time. Students trusted ChatGPT's answers without verification, claimed credit for solutions, and reported no difficulty understanding its responses.

The study also investigated the level of confidence both student groups had in their outcomes (Table 10). Students were questioned regarding their level of confidence in both academic and real-world professional settings. There were no differences between the two groups, although as could be predicted, students felt more confident in an academic atmosphere where less responsibility was suggested than in a professional one.

Table 10. Confidence expressed in the results obtained in the case study.

	Confidence in the academic field	Confidence in a professional environment
ChatGPT users	4.21	3.54
Non ChatGPT users	4.31	3.62

Contrary to the assumption that GPA or subject grade correlates with confidence, the results fail to support this, as the statistical significance exceeds 0.05. The T-test for independent groups does not offer any clarity on this matter either. Therefore, the initial assumption P.j): "Students who use ChatGPT would exhibit lower confidence in the results due to their inability to oversee or verify them", cannot be confirmed or rejected.

As we expected, higher grade expectations lead to greater confidence for both academic (0.893) and professional (0.809) purposes, and these correlations are statistically valid in both groups.

The results highlight two perceptions:

a) Accuracy of results: ChatGPT users exhibit high self-confidence, often overestimating the accuracy of their results due to a "blindness to fraud," despite a mismatch with actual performance.

b) Translation of results: This inflated confidence has little impact on their perceived utility or confidence in academic and professional applications.

To conclude the analysis of the results obtained in the study, a table is presented that summarizes the confirmation or not of the assumptions (Table 11).

Table 11. Summary of assumption rejection or confirmation and employed technique parameters.

	Statistical technique	Status	Reason
P.a)	T-means for independent groups	Rejected	Cohens' D > 2
P.b)	Correlation with GPA	Rejected	sig = +0.435. ChatGPT is a confounding variable.
P.c)	T-Test Independent samples	Rejected	Not attributable to ChatGPT Cohen's D = 0.28
P.d)	T-Test Independent samples	Rejected	Not attributable to ChatGPT Cohen's D = 0.34
P.e)	Correlation with GPA	Rejected	Sig = +0.431. ChatGPT is a confounding variable.
P.f)	T-Test Independent samples	Rejected	Not attributable to ChatGPT Cohen's D = 0.17

	Statistical technique	Status	Reason
P.g)	Chi-square	Rejected	Count of ChatGPT users is lower than count of SPSS users.
P.h)	T-Test	Confirmed	Cohens' D = 2.52
P.i)	T-Test	Confirmed	Glass' Delta = 3.228
P.j)	T-Test	Neither confirmed nor rejected	Sig > 0.05 in all tests

4. Conclusions

AI, particularly NLP models, is reshaping higher education, raising concerns about data security, performance, and legitimacy in educational settings. Educational institutions and their members bear the responsibility of ensuring that AI benefits both students and educators. In this sense, objective research is essential in decision-making rather than relying on subjective or persuasive expert's arguments about AI.

The study originally aimed to assess students' effort and outcomes when using AI, but it made an unexpected discovery concerning the confidence exhibited when using Natural Language Processing (NLP) AI.

The study presents two main areas of investigation. Firstly, it dissects the competencies required at a university level to examine them. The results indicate that the use of ChatGPT alone does not improve competency outcomes individually. Instead, students' prior knowledge of the subject appears to be a more explanatory factor for academic performance when considering each competency separately. However, when measuring overall test performance without breaking down competencies, ChatGPT usage negatively affects outcomes.

These results may stem from tool-related issues and from the ways students interact with AI, highlighting the need to train students in the effective and critical use of AI-based tools. In this regard, recent studies have emphasized that the educational value of ChatGPT depends largely on how students and educators harness their potential within structured learning processes (Zhu et al., 2023).

Although previous studies have highlighted ChatGPT's potential as a self-learning and academic support tool in higher education (Nisar & Aslam, 2023), our findings suggest that its effectiveness strongly depends on students' ability to critically evaluate and validate AI-generated outputs. In their study Aiyappa et al. (2023) argue that, despite their apparent usefulness evaluating ChatGPT and similar large language models reveal limitations associated with data contamination, as they are trained in the entire web. However, in our investigation, the main problem appears to emerge at a later stage, beyond the fact-checking process itself (Irfan & Murray, 2023).

According to our findings, a more fundamental issue exists, one that can bemore directly addressed by educators, institutions, and students. Students tended to place an excessive degree of trust in responses perceived as personalized and authoritative, almost as if they were consulting a personal expert. This behavior is consistent with the phenomenon of cognitive offloading, whereby the delegation of cognitive tasks to external tools reduces individuals' engagement in independent reasoning and is associated with a measurable decline in critical thinking skills (Gerlich, 2025). While GPA may explain some competency-related outcomes, ChatGPT appears to have limited influence on the remaining abilities. Consequently, the presence of a conversational and seemingly tailored AI system may overshadow students' previously acquired analytical and critical-thinking skills.

The second area of study focuses on students' perceived effort. Students using ChatGPT reported lower effort levels, particularly those with better prior knowledge of the subject. Interestingly, the number of questions they asked ChatGPT did not affect their total response rate. Students who reported less effort and used ChatGPT had higher grade expectations and displayed greater confidence in their responses.

Thus, we began to suspect that there was a hidden effect in the use of the tool. AI tools with NLP models are designed to engage in conversations with users, conveying a sense of fluidity and ease in the exchange that may reinforce the perception of the validity of the results obtained. Students tend to consider that they don’t get an answer gathered from the internet (as in a browser), but an answer created specifically by Intelligence just for them and for the occasion.

At this point, we explored the concept of Illusion of Explanatory Depth (Rozenblit and Klein, 2002) to attempt to explain our findings. According to the authors, individuals may believe they possess knowledge of the world simply because a certain social opinion state (from a group aligned with their beliefs) reinforces explanatory knowledge. Even if the person could verify the facts, this makes them think of something that is untrue overall. However, this heuristic did not entirely correspond to our findings, as it did not necessarily involve a social opinion state or an explanatory narrative.

The observed, and measured effect and its means (personable dialogue, low friction in responses, and individualized results) closely align with what Thaler and Sunstein termed a "Nudge" (Thaler & Sunstein, 2008). This refers to a choice architecture designed to guide our actions and perceptions beneath our rational radar.

Later, both Yeung (2017) and Lanzing (2019) ventured to suggest the category of "Hypernudging." In this model, choice architecture does not merely appeal to basic mechanisms shared by everyone; instead, it becomes individualized through algorithms and Big Data, creating a decision-making space that is intimate, personal, and unique.

Students prioritize their trust in a system that whispers in their ear like an expert over their own knowledge (even when they possess it). They do not think to consult other sources or verify information themselves, even though it would be very easy to do so. There is a "glow" in the interaction with AI—which would not be an exaggeration to call trust—that renders them "Blind to Fraud."

The effect we found was accurately observable in the final question of the case study, which concerned the construction of a buyer persona, where the response rate of students who used ChatGPT was high, but 100% of their responses were incorrect or completely misaligned with the case study. Although they already had the knowledge, they didn't even check whether the answer was true or not. In our opinion the problem is that the answer is plausible and tailored specifically for the case.

The observed phenomenon that we termed "Blindness to Fraud" appears to be unique to the use of AI tools in the context of NLP. It manifests as an initial perception of reduced effort, primarily attributed to tool usage rather than the specific task at hand. This reduced effort subsequently leads to inflated grade expectations, creating an unwarranted sense of self-attribution of achievement. Students who expected higher grades tended to attribute a significant share of the work to themselves when dividing it between themselves and the AI.

In contrast to the "Illusion of explanatory," the "Blindness to Fraud" phenomenon allows individuals to wholly attribute the answers or explanations to themselves, leading to a moral reflection that we shall set aside here for the sake of space. The private nature of AI interactions plays a significant role in this self-attribution, as it makes it easy to erase traces of external input. Understanding this phenomenon goes beyond teaching students to ask questions or verify results. It appears to be a bias originating from the interaction with AI systems delivered through NLP.

Therefore, we believe that a new subtask emerges for both students and educators, as well as institutions. Joyner (2023) suggests that alongside training in critical thinking and the capacity to challenge answers, there should be an emphasis on critically evaluating the processes that produce those answers. Utilizing ChatGPT effectively entails developing a specific skill set, particularly two key abilities that should be cultivated during the university experience: the skill to pose inquiries in a structured and conducive manner towards achieving objectives, and the capacity to interpret outcomes with coherence, problem-solving proficiency, and reliability, among other attributes.

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ARTICLE / ARTÍCULO

Evaluation of Visual Metaphors of School Coexistence Using Generative Artificial Intelligence and Expert Judgment

Evaluación de metáforas visuales sobre convivencia escolar con inteligencia artificial generativa y juicio experto

Karla Karina Ruiz-Mendoza[1], Luis Horacio Pedroza-Zúñiga[2] & Héctor Manuel Rodriguez-Figueroa[3]

Abstract: This study compares agreement and reliability between human judges and GAI models when evaluating visual metaphors of school coexistence, understood as graphic representations that translate institutional experiences into symbolic scenes (a ranch with corrals, a market with stalls, and countries/faculties). The design was comparative, with repeated measures across three metaphors and the transcribed verbal explanations provided by the students who produced them in focus groups. Six human experts participated (18 ratings) and five LLMs (ChatGPT-5, ChatGPT-5 Pro, ChatGPT-o3, DeepSeek, Gemini 2.5), with five runs per model (75 ratings). The rubric included a global judgment (1-3), binary indicators, and 10 Likert items (1–5). Ordinal alpha, Cohen kappa, Fleiss kappa, Krippendorff alpha, and a p × r G-study with a D-study for human-GAI mixtures were estimated. The input was not identical across models: ChatGPT variants worked with image and description, whereas DeepSeek and Gemini evaluated the narrative description and transcript. Therefore, the results are interpreted as a baseline situated in the versions and conditions analyzed, not as a definitive conclusion about all current or future multimodal systems. Findings showed that GAI produced more words than human experts, although length was treated as a descriptive indicator rather than a measure of quality or depth. The Coexistence Index was higher for humans, especially in Metaphor 2 (Delta = +0.91). The D-study indicated that 1–2 human experts plus around 10 GAI runs reach $G \geq 0.95$. ChatGPT-5 Pro was the model closest to human consensus. The study provides a reference point for future pedagogical analysis of student productions supported by GAI.

Keywords: Artificial Intelligence, Educational Assessment, Interrater Reliability, Scoring Rubrics, Visual metaphor, School Culture, Test Reliability.

Resumen: Este estudio compara coincidencias y confiabilidad entre jueces humanos y modelos de IAG al evaluar metáforas visuales de convivencia escolar, entendidas como representaciones gráficas que trasladan experiencias institucionales a escenas simbólicas (rancho con corrales, mercado con puestos y países-facultades). El diseño fue comparativo, con medidas repetidas sobre tres metáforas y la explicación verbal transcrita de los estudiantes que las elaboraron en grupos de discusión. Participaron seis personas expertas (18 valoraciones) y cinco LLM (ChatGPT-5, ChatGPT-5 Pro, ChatGPT-o3, DeepSeek, Gemini 2.5), con cinco ejecuciones por modelo (75 valoraciones). La rúbrica incluyó juicio global (1-3), tres indicadores binarios y 10 ítems Likert (1-5). Se estimaron alpha ordinal, kappa de Cohen, Fleiss kappa, alpha de Krippendorff y una G-study p x r con D-study para mezclas humano-IAG. Se aclara que la entrada no fue idéntica para todos los modelos: las variantes de ChatGPT trabajaron con imagen y descripción, mientras que DeepSeek y Gemini valoraron la descripción narrativa y la transcripción; por ello, los resultados se interpretan como línea base situada en las versiones y condiciones analizadas, no como conclusión definitiva sobre todos los sistemas multimodales actuales o futuros. Los hallazgos muestran que las IAG produjeron más palabras que las personas expertas, aunque la extensión se trató como indicador descriptivo y no como medida de calidad o profundidad. El índice de Convivencia fue mayor en humanos, sobre todo en la Metáfora 2 (Delta=+0.91). El D-study indicó que 1-2 personas expertas + alrededor de 10 ejecuciones de IAG alcanzan G >= 0.95. ChatGPT 5 Pro fue el modelo más próximo al consenso humano. El estudio aporta un referente para el análisis pedagógico futuro de producciones estudiantiles con apoyo de IAG.

Palabras-clave: Inteligencia artificial, Evaluación educativa, Confiabilidad interjueces, Rúbricas de evaluación, Metáfora visual, Cultura escolar, Confiabilidad de la medición.

1. Introduction

In recent years, the expansion of Generative Artificial Intelligence (GAI), based on Large Language Models (LLMs), has transformed information-seeking practices, writing processes, and learning support in higher education (Kosmyna et al., 2025; Nasr et al., 2025; Zhai et al., 2024). Beyond the informal use of chatbots to complete assignments or draft texts, a body of research on the use of GAI in educational assessment processes is beginning to emerge: automated generation of test items and rubrics (Arif et al., 2024; Doughty et al., 2024; May et al., 2025; Mistry et al., 2024; Scaria et al., 2024), grading of essays and academic texts (Bouziane & Bouziane, 2024; Bui & Barrot, 2025; Usher, 2025), written feedback on student work (Atasoy & Arani, 2025), and evaluation of multimodal products such as images or visual compositions (Liao et al., 2025; OpenAI, 2025).

In the generation of instruments, several studies have shown that LLMs can rapidly generate item banks aligned with curricular specifications and theoretical frameworks, opening the possibility of scaling assessment design processes (Arif et al., 2024; Doughty et al., 2024; Mistry et al., 2024; Scaria et al., 2024). Nevertheless, they also document significant rates of formal errors, content misalignment and problematic distractors when an expert human editing is absent, including cases in which up to 80% of the items require a substantive correction (May et al., 2025). Similarly, in the assessment of written work, GAI has been found to align with teachers' evaluations regarding mechanical criteria—grammar, spelling, and structure—but to diverge in the assessment of thematic coherence, conceptual depth and contextual adaptation (Bouziane & Bouziane, 2024; Bui & Barrot, 2025; Usher, 2025). These findings have reinforced recommendations to adopt hybrid models in which GAI systems contribute speed and operational detail, while human judgment ensures content validity and pedagogical sensitivity (Artsi et al., 2024; Kiryakova, 2025; Kıyak & Emekli, 2024; Laupichler et al., 2024; Law et al., 2025).

Despite this progress, the available evidence has mainly focused on textual products and relatively standardizable performance dimensions, such as linguistic accuracy and achievement in cognitive content (Atasoy & Arani, 2025; Bui & Barrot, 2025). Much less is known about the performance of GAI as an evaluator in tasks involving visual inputs and complex socio-affective contexts, for example school dynamics, equity or power relations in school contexts (Fierro-Evans & Carbajal-Padilla, 2019; Rodríguez-Figueroa, 2019, 2021). In addition, most studies have been limited to calculating correlations or inter-rater agreement coefficients (κ, α) between humans and AI, without analyzing the overall stability of the scoring system or the optimal combinations of human and automated evaluators from advanced reliability frameworks such as Generalizability Theory (Brennan, 2001; Krippendorff, 2004; Shavelson & Webb, 1991).

This gap is especially significant in the field of school dynamics, which refers to the everyday interpersonal practices that shape life within educational institutions, distinct from—although closely connected to—their institutional management (Fierro-Evans, 2013; Fierro-Evans & Carbajal-Padilla, 2019). From a sociocultural perspective, school dynamics incorporate normative dimensions—justice, equity, and lasting peace—and structural dimensions—power distribution and forms of regulation—that go beyond the direct observation of specific behaviors and require the articulation of context, structure, and social action (Giddens, 1998; Rodríguez-Figueroa, 2019, 2021; Weiss, 2015). In higher education, moreover, the literature on school dynamics is less extensive than in basic education, despite the fact that universities are key spaces for democratic formation, inclusion, and youth rights (Hirmas & Carranza, 2009; López et al., 2023).

In this sense, one way to visualize the function of metaphors is through the three-level sociocultural framework—context, structure, and social action—which organizes information and guides interpretation (see Figure 1) (Rodríguez-Figueroa, 2019). In simple terms, context situates the school within its physical and social environment, as well as the profile of its agents; structure includes "learning and educating to live together" (norms and institutional management); and social action refers to "living together" in everyday interaction.

In this context, visual metaphors created by university students constitute a valuable means of exploring how school dynamics and their tensions are represented. Different from standardized questionnaires, metaphors make it possible to simultaneously represent context, structure, and social action within a single scene, requiring the evaluator—whether human or a GAI model—to connect visible elements with interpretations related to equity, segregation, hierarchies, or practices of peace (Delors et al., 1996; Rodríguez-Figueroa, 2019; Weiss, 2015). Precisely because of their complexity, these metaphors pose challenges for GAI and provide an ideal "testing ground" for evaluating its interpretative capacities in relation to experts in school dynamics (Bertling et al., 2025; Caeiro Rodríguez et al., 2021).

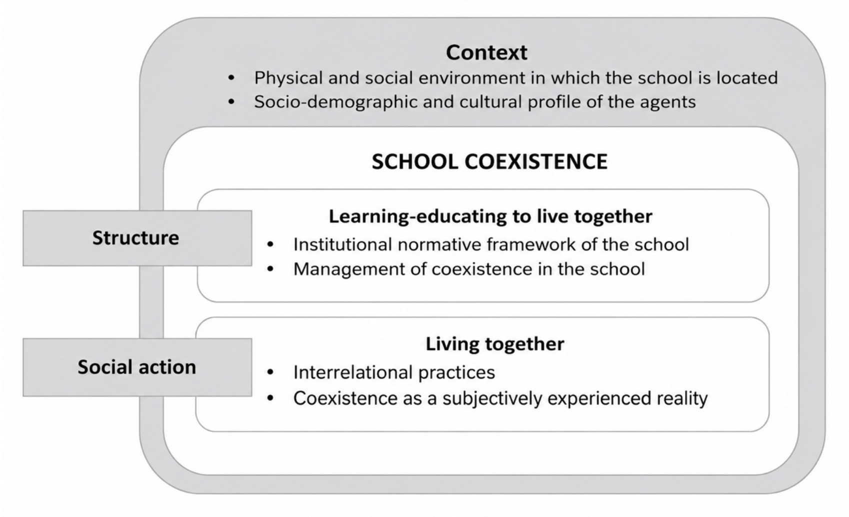

Figure 1. School dynamics from a sociocultural perspective. Theoretical framework for the study of school dynamics from a sociocultural perspective (Rodríguez-Figueroa, 2019, p. 35).

To clarify the object of analysis, this article defines a visual metaphor of school dynamics as a graphic representation produced by students in which a domain of everyday experience (for example, a ranch, a market or a territorial organization divided by countries/faculties) is used to express how relationships, norms, conflicts, inclusion or exclusion within the university are perceived. The evaluation does not focus on the aesthetic quality of the image, but rather on the correspondence between visible or described elements and sociocultural dimensions of school dynamics: everyday interaction, rules, distribution of power, participation, equity and forms of conflict resolution or absence thereof. The three metaphors analyzed are detailed in Appendix 1 and summarized in Table 1.

However, no studies have yet systematically compared the evaluations produced by GAI models and panels of experts regarding visual metaphors of school dynamics in higher education, nor examined the overall reliability of these scoring systems through Generalizability Theory. Most studies on GAI-assisted assessment focus on textual tasks and are limited to reporting bivariate agreement indicators, without estimating how many and what types of evaluators—humans and/or automated—are necessary to obtain sufficiently stable scores (Atasoy & Arani, 2025; Brennan, 2001; Krippendorff, 2004; Shavelson & Webb, 1991).

This study seeks to help fill this gap. In general terms, our goal is to compare the reliability of human evaluators and GAI models in interpreting the three visual metaphors of school dynamics created by students from three Mexican universities, identify differences and similarities in their closed-ended evaluations, and estimate—through Generalizability Theory—the combination of evaluators that produces the most reliable scores (AERA, APA, & NCME, 2014; Brennan, 2001; Shavelson & Webb, 1991). More specifically, we ask: (a) to what extent humans and GAI agree in their interpretation of observable and normative dimensions of school dynamics; (b) how stable the scoring system is when exclusively human, exclusively automated or mixed panels are used; and (c) which combinations of human and GAI evaluators maximize reliability without losing the contextual grounding provided by expert experience.

2. Methodology

Based on the objective of the study, the research follows a quantitative repeated-measures design involving three stimuli and a multi-rater panel. The analysis was conducted following prior focus groups conducted at three universities from different regions of Mexico, where metaphors aligned with the social action perspective were obtained; each image was created by groups of four students. The universities were: a private university in the Bajío region, "ranch with corrals" (metaphor 1); a public university in the Central-West region, "market with stalls" (metaphor 2); a public university in northwestern Mexico, "countries-faculties" (metaphor 3); see Appendix 1 and Table 1. The study does not aim to exhaust all possible modes of visual analysis, but rather to test a comparative evaluation between human evaluators and GAI models using student-produced metaphors. To estimate system reliability, Generalizability Theory was applied using a crossed $p \times r$ design (object of measurement = survey $\times$ Likert item, 30 units; facets: images (p), evaluator (r) and $p \times r$ interaction). This decision followed common guidelines in quantitative research and educational assessment (Creswell & Creswell, 2018; AERA, APA, & NCME, 2014; Shavelson & Webb, 1991; Brennan, 2001).

Table 1. Visual metaphors analyzed and their relevance for rating.

Metaphor	Visual domain	Synthetic description	Relevance for rating
1. Ranch with corrals	Ranch/corrals	University dynamics are represented through differentiated spaces, social groupings and boundaries between actors.	It allows the assessment of segregation, sense of belonging, interaction among groups and symbolic or institutional boundaries.
2. Market with stalls	Campus market	The university is represented as a shared circulation space, exchange, diversity of stalls, and everyday coexistence.	It allows the analysis of cooperation, everyday social dynamics and tensions within shared spaces, participation, and integrated diversity
3. Countries-faculties	Map/territory	Each faculty or group is shown as a territory with differentiated boundaries, identities and relationships.	It allows the assessment of group identities, hierarchies, intergroup distance, distribution of power and inequality.

2.1. Participants

The study was conducted with two groups: six experts in school dynamics (one evaluation for each metaphor; 18 human evaluations) and five GAI models (ChatGPT 5, ChatGPT 5 Pro, ChatGPT o3, DeepSeek, Gemini 2.5 Flash). The ChatGPT 5 Pro version corresponded to a paid license. Each model performed five runs per metaphor (75 GAI evaluations; see Table 2). To estimate model consistency, each run was treated as if it were an independent evaluator (25 GAI evaluators per metaphor). The human evaluators were researchers with demonstrated experience in studies and/or interventions related to school dynamics: two from Chilean universities and four from Mexico. The human panel was selected using expert-judgment sampling. It included evaluators with demonstrated experience in studies and/or interventions related to school dynamics in higher education. The study was non-anonymous (name, area of expertise and role were recorded for traceability purposes) and informed consent was obtained. No missing data were recorded in the closed-ended items.

Table 2. Evaluations per rubric.

Metaphor	Humans (n)	GAI (n conversations)	Total
1	6	25	31
2	6	25	31
3	6	25	31
Total	18	75	93

2.2. Instrument

The judges were provided with a Metaphor Analysis Guide, structured by experts in school dynamics and using the same sequence for all three metaphors (see Table 3): a) a non-scored descriptive section (M0) used to inventory visual evidence without interpretation; (b) scored dimensions (D1–D6), which combined an inductive global judgment of the type of coexistence (3.1, 1–3 scale: poor–fair–good) with binary indicators of key processes (4 subgroups: 7.1 violence containment, 8.1 constructive resolution, 9.1 lasting peace; 0 = No / 1 = Yes) and a set of 10 Likert-scale propositions (1–5) capturing nuances of coexistence (cooperation, antagonism, participation, integrated diversity, segregation, hierarchical power, peaceful coexistence, equity, inequality, direct violence); and (c) non-scored support fields (M1) used to briefly justify judgments and ensure traceability.

Table 3. Assessment Guide for Visual Metaphors of School Dynamics: Construct, Dimensions, Indicators and Coding.

Dimension / module of the guide	What it evaluates (operational definition)	Indicators / Items (codes)	Type of response and coding
M0. Objective description (not scored)	Inventory of visual elements without interpretation to support subsequent judgment.	List of objects, actors, colors, and spatial arrangement (1 and 2).	Open-ended text (descriptive evidence).
D1. Type of coexistence (3.1)	Global inductive assessment of the represented coexistence.	3.1 "Type of coexistence": poor (disrespect/violence, separated subgroups), fair (mix of positive and negative practices), good (respect, inclusion, participation, communication, peaceful coexistence).	Ordinal 3-point scale → 1 = poor, 2 = fair, 3 = good.
D2. Subgroups (4)	Presence of student separation into small "groups/cliques".	4 Informal subgroups.	Binary → 0 = No (including "Not sure"), 1 = Yes.
D3. Violence containment (7.1)	Presence of immediate responses to situations that disrupt coexistence.	7.1 Containment scenarios	Binary → 0 = No, 1 = Yes.
D4. Constructive resolution (8.1)	Practices of dialogue, negotiation, mediation or cooperation for conflict resolution.	8.1 Constructive resolution.	Binary → 0 = No, 1 = Yes.
D5. Lasting peace (9.1)	Transformation oriented toward equity, inclusion, and sustained participation.	9.1 Conditions for lasting peace	Binary → 0 = No, 1 = Yes.

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Dimension / module of the guide	What it evaluates (operational definition)	Indicators / Items (codes)	Type of response and coding
D6. Dimensions of coexistence (10-item Likert index)	Presence of specific relational practices/structures that, when aggregated, estimate the Coexistence Index.	10.1–10.10: cooperation (+), antagonism (–), active participation (+), integrated diversity (+), segregation/marginalization (–), hierarchical/impositional power (–), peaceful coexistence (+), equity (+), inequality (–), direct violence (–).	Likert scale 1–5 ("strongly disagree" to "strongly agree").
M1. Supporting fields (not scored)	Textual support of judgments to ensure traceability.	3.2 / 7.2 / 8.2 / 9.2 Brief justifications.	Open-ended text (rater justification anchors).

2.3. Procedure

As shown in Figure 2, the procedure consisted of five phases. First, the three metaphors derived from the focus groups were selected. Next, the guide was applied to the expert evaluations and the five GAI models were executed using identical instructions. However, an important methodological difference was observed: ChatGPT variants worked with image and description, whereas DeepSeek and Gemini did not directly observe the image; instead they produced their evaluations based on the narrative and transcriptions provided. Therefore, the comparison should not be interpreted as a strictly equivalent competition between multimodal systems, but rather as an analysis of how different input modalities –visual plus textual versus text-mediated input– affect metaphor evaluation. This clarification also situates the temporal scope of the study: given the rapid evolution of GAI, later versions will likely incorporate improvements in visual processing and multimodal interpretation.

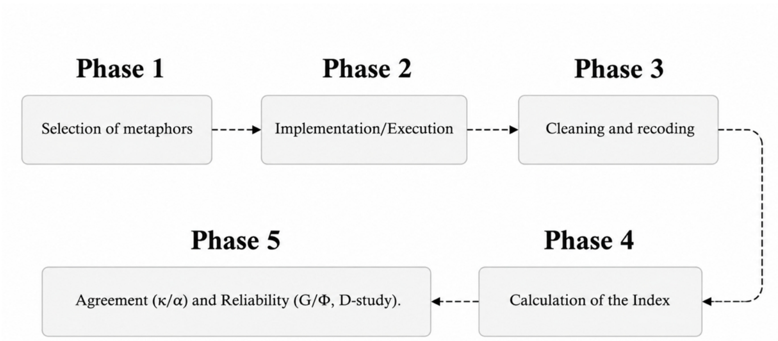

Figure 2. Study procedure

In a third stage, data cleaning and recoding were performed: a unified database was created, headers were standardized and reverse-coded items were documented. For the main analyses, closed-ended items (3.1, 4, 7.1, 9.1, and 10.1–10.10) were selected, and the total number of words per open-ended item (1, 2, 3.2, 5, 6.1, 6.2, and 6.4) was computed. This word count was retained as a descriptive indicator of response style and traceability of justifications, not as a measure of depth, quality or validity of the analysis. Subsequently, the Coexistence Index was calculated for each rater and metaphor based on items 10.1–10.10. Finally, agreement between human and GAI was estimated per item and the reliability of the scoring system was assessed.

2.4. Data analysis

Description. Means and standard errors of the Coexistence Index were explored by metaphor and type of rater. Text length was examined only as a descriptive variable to characterize response styles (more concise or more extensive), without assuming that a higher number of words implied greater depth or quality. For the Likert-scale item block, internal consistency was estimated using ordinal alpha, which is appropriate for ordered categorical response formats (Gadermann, Guhn, & Zumbo, 2012).

- Qualitative review of open-ended responses. To complement word count analysis, a qualitative content review was conducted on open-ended fields 1, 2, 3.2, 5, 6.1, 6.2, and 6.4, understood as systematic and context-sensitive inference processes based on textual units (Krippendorff, 2004). The review was organized by item and type of rater, and aimed to identify the predominant function of the responses—descriptive, interpretive, justificatory, and argumentative—as well as their degree of conciseness, recurrent thematic cores and the way in which each group linked visual or textual evidence with constructs of school dynamics. This procedure did not replace statistical analyses; rather it served to distinguish textual length from interpretive depth and argumentative quality.

- Inter-rater agreement. The degree of agreement between human evaluators and GAI was assessed using Cohen's kappa: a quadratic weighted kappa for ordinal variables (Likert scale items) and unweighted kappa for binary variables (Cohen, 1960, 1968). For multi-rater agreement on binary variables, Fleiss' kappa was applied (Fleiss, 1971). In addition, Krippendorff's alpha was used to accommodate mixed measurement levels (Krippendorff, 2004).

- Reliability. A G-study was conducted to decompose variance into facets of images/stimulus (p), rater (r), and their interaction ($p \times r$) and to estimate generalizability coefficients (G, relative reliability) and phi coefficients (Φ, absolute reliability) (Shavelson & Webb, 1991; Brennan, 2001). Based on these variance components, a D-study was performed to project expected reliability under different combinations of human and GAI raters.

- Model ranking. A composite score was constructed to rank GAI models (70% Likert-scale κ, 20% binary κ, 10% Spearman's ρ of the index) and consistency of rankings was evaluated using rank correlation (Spearman, 1904).

- Software and visualization. Analyses were conducted in Python, specifically using Google Colab, with pandas and Matplotlib (Hunter, 2007; McKinney, 2010). Figures followed established guidelines for scientific visualization and graphical excellence (Cleveland, 1993; Tufte, 2001; Wilkinson, 2005).

It is important to emphasize that the statistical results were organized by levels of evidence to avoid letting a single coefficient dominate the interpretation. Ordinal alpha assessed the internal consistency of the Likert block; Cohen's kappa compared human-GAI agreement and mixed measurement levels; the G-study and D-study evaluated the overall stability of the scoring system and the combination of raters; and the ranking model was used solely as an indicator of proximity to human consensus, rather than as an absolute measure of model superiority.

3. Results

The first analysis was descriptive and had a limited scope: word counts were calculated to characterize response styles of both human evaluators and models, not to infer greater depth, quality or validity.

3.1. Word count per item by rater type

The first analysis was descriptive and had a limited scope: word counts were calculated to characterize response styles of both human evaluators and models, not to infer greater depth, quality or validity. Table 4 presents these results in terms of means. GAI systems produced longer responses than the human panel across all sections of the instrument. Overall, GAI models produced 72.4 words in Description, 85.4 in Interpretation, 46.2 in Justification (3.2), 9.6 in Actors (5), 14.6 in Attitudes (6.1), 15.0 in Behaviors (6.2) and 24.0 in Conflicts (6.4), compared to 38, 47, 29, 4, 5, 5 and 3 words for human responses, respectively. This represented approximate increases of 1.9x (Description), 1.8x (Interpretation), 1.6x (Justification), 2.4x (Actors), 2.9x (Attitudes), 3.0x (Behaviors) and 8.0x (Conflicts), relative to human evaluators.

Table 4. Average word count per item by GAI models and humans.

Model	ChatGPT 5	ChatGPT 5 Pro	ChatGPT o3	Deep-seek	Gemini 2.5	Average IAG	Humans
1. Description	78	84	71	52	77	72.4	38
2. Interpretation	85	67	83	74	118	85.4	47
3.2. Justification	41	41	31	47	71	46.2	29
5. Actors	14	15	5	9	5	9.6	4
6.1 Attitudes	15	18	9	13	18	14.6	5
6.2 Behaviors	16	17	8	11	23	15	5
6.4 Conflicts	22	22	21	12	43	24	3

Among the models, Gemini 2.5 was the most verbose in the interpretive and behavioral sections (Interpretation = 118; Justification = 71; Behaviors = 23; Conflicts = 43). In contrast, ChatGPT 5 Pro produced the most extensive responses in the Description dimension of the metaphors (84) and in the Actors dimension (15), while also tying for the highest value in Attitudes (18), alongside Gemini 2.5. As for DeepSeek, it stood out only in Justification (47), while ChatGPT o3 tended to produce shorter responses in contextual and behavioral variables (Actors = 5; Attitudes = 9).

To complement the word count analysis presented in Table 4, a qualitative review of open-ended responses was conducted, using the same items to ensure comparability. This review does not assume that greater length corresponds to higher quality or depth; instead, it makes it possible to distinguish whether responses were primarily descriptive, interpretive, justificatory or inferential, as well as whether they tended toward synthesis, enumeration or argumentation.

Table 5. Qualitative synthesis of open-ended responses by rater type.

Open item	Experts	GAI/LLM	Comparative Reading
1. Description	Selection of key elements and features with interpretive value: spaces, boundaries, groupings, and the composition of the scene.	A more comprehensive and organized inventory of objects, colors, positions, actors, and spatial relationships.	The main difference was between prioritizing relevant evidence and providing a more exhaustive list.
2. Interpretation	Further reading on coexistence, separation, belonging, indifference, integration, and exclusion.	Identification of general patterns: diversity, groupings, partial coexistence, and tensions between groups.	There was greater contextual density in the expert panel and greater categorical systematicity in the models.
3.2. Justification	More nuanced arguments; some responses acknowledged the ambiguity or limitations of the scale used to classify coexistence.	More consistent justifications, generally presented as a balance between positive and negative factors.	The GAI systems provided regular justifications; the experts expressed greater caution in the face of visual ambiguity.
5. Actors	Brief and discreet identification: students, the university community, the institution, and, in some cases, faculty members or administrators.	Broader list: students, groups, faculty, administrators, the institution, and the university community.	The models expanded the repertoire, but with a higher risk of inferring non-explicit actors.
6.1. Attitudes	Emphasis on indifference, belonging, distance, rivalry, acceptance, or isolation, with a relational focus.	Organization into explicit categories: group pride, separation, prejudice, rivalry, inclusion, or the need for unity.	They agreed on membership and separation; the expert panel provided a more relational perspective, while the models offered a more categorical framework.
6.2. Behaviors	Greater caution was exercised when no explicit actions were taken; limited interaction, isolation, or a lack of sufficient evidence were noted.	Translating the metaphor into concrete actions: staying in groups, moving around, competing, collaborating, or sharing spaces.	The models inferred more behaviors; the experts avoided overinterpreting ambiguous scenes.

Open item	Experts	GAI/LLM	Comparative Reading
6.4. Conflicts	Identifying latent conflicts: segregation, indifference, inequality, lack of integration, or exclusion.	More explicit identification of conflicts: rivalry, competition, separation, tension between diversity and integration, or inequality.	The GAI systems produced additional recommendations; the expert panel tended to focus more on social and regulatory implications.

Overall, the GAI/LLM groups produced more extensive, organized, and enumerative responses, particularly regarding descriptions, actors, behaviors, and conflicts. The experts were more concise, but often more selective, cautious, and context-sensitive, particularly when the questions required justifying coexistence, interpreting attitudes, or assessing latent conflicts. Therefore, the comparison should be interpreted as a difference in the nature of the analysis: the GAI systems provide comprehensiveness and systematicity, while the expert panel offers prioritization, contextual caution, and sensitivity to social and normative dimensions.

3.2. Coexistence Index: Differences Between Humans and GAI

According to the Coexistence Index, the average reveals gaps between humans and GAI systems (Table 6; see Figure 6): the index was consistently higher in the scores assigned by the expert panel. In Metaphor 2, the difference was significant in favor of the human panel (Delta = +0.91; 4.28 vs. 3.37). In Metaphors 1 and 3, the differences were small (Delta = +0.15 and +0.21, respectively), meaning they practically coincide in their interpretation of the level of coexistence. When the image or its description offered integrative cues (e.g., shared spaces, movement, or groups), the expert panel assigned higher scores, while the models generated more conservative scores. This difference is significant because it defines the type of inferences that LLMs make regarding social constructs: it is not merely a matter of detecting objects, but of weighing their pedagogical and normative significance.

Table 6. Average coexistence rates.

Metaphor	Humans (Δ)	GAI (Δ)	Differences (H–GAI)
1	2.78	2.63	+0.15
2	4.28	3.37	+0.91
3	3.47	3.26	+0.21

Note. Scores on a scale of 1–5. A positive difference indicates a higher human score compared with the GAI.

Breaking down the GAI models, Table 7 shows that ChatGPT 5 Pro and ChatGPT o3 were the closest to human evaluations, according to the MAE (0.307 and 0.344, respectively), with small deviations in M1 and M3—and even slight overestimates (Δ<0) in some cases: o3 at M1=–0.117 and M3=–0.113, and 5 Pro at M3=–0.193—while at M2 both underestimated coexistence (0.723 and 0.803). In contrast, DeepSeek (MAE=0.758) and Gemini 2.5 Flash (MAE=0.571) showed the greatest discrepancies, with systematic underestimation across all three metaphors (e.g., M2=1.023 for both and M3=0.547/0.567), and ChatGPT 5 exhibited an intermediate pattern (MAE=0.424) but with a very large gap in M2=0.983.

In terms of the relative order of metaphors, ρ=1.00 for ChatGPT 5, DeepSeek, and Gemini 2.5 indicates that they reproduced the order observed in the human consensus (M1–M3 ranking), although they were off-scale (high deltas), whereas 5 Pro and o3 (ρ=0.50) were closer in magnitude but less stable in the ranking. Considering the index's 1–5 scale and adopting an operational threshold of Δ≥0.50 as a relevant difference for decision-making, the gaps were substantial in M2 for four out of five models and, additionally, in DeepSeek/Gemini for M3; therefore, the differences between models and the human panel were materially significant (especially in M2), even though formal statistical significance is not estimated here due to the limited number of metaphors (N=3).

Table 7. Differences in the index between the GAI model and humans.

GAI Model	M1 (Δ)	M2 (Δ)	M3 (Δ)	MAE	ρ Coexistence Index (vs. H)
ChatGPT 5	0.043	0.983	0.247	0.424	1.00
ChatGPT 5 Pro	0.003	0.723	−0.193	0.307	0.50
ChatGPT o3	−0.117	0.803	−0.113	0.344	0.50
DeepSeek	0.703	1.023	0.547	0.758	1.00
Gemini 2.5 Flash	0.123	1.023	0.567	0.571	1.00

Note: Positive Δ = the human score was higher than that of the model (underestimation by the AI); Negative Δ = the model overestimated compared to humans. MAE: mean absolute error between scores (average of human (H) and AI scores across the three metaphors). ρ: Spearman's rank correlation coefficient between average scores per metaphor (human compared with the GAI model).

On the other hand, as shown in Table 8, the agreement between humans and GAI on these scales was of moderate magnitude (approximate average Cohen's kappa = 0.475; approximate Krippendorff's alpha = 0.236), indicating partial alignment with some loss of detail across certain dimensions. When the cues present in the metaphors are behavioral and observable (e.g., acts of cooperation, antagonistic behaviors, or indicators of active participation), alignment increases considerably—cooperation reached kappa = 0.80 (alpha = 0.572), while antagonism and active participation had an approximate kappa of 0.67. In contrast, items requiring normative judgments or inferences about social structures (equity, inequality, hierarchical power) showed low agreement (kappa ≤ 0.25), indicating less concordance between the models and the expert panel in interpreting nuances related to justice and the distribution of power. In other words, the models detect visible groupings or inequalities, but do not reproduce the normative evaluations provided by the experts with the same fidelity.

Table 8. Results for items using a Likert scale.

Item (summary)	Cohen's κ (H vs GAI)	Krippendorff's α
Cooperation	0.80	0.572
Antagonism	0.67	0.238
Active participation	0.67	0.409
Inclusive Diversity	0.55	0.354

Item (summary)	**Cohen's κ (H vs GAI)**	**Krippendorff's α**
Segregation/marginalization	0.25	0.390
Hierarchical authority	0.25	0.128
Peaceful coexistence	1.00†	0.105
Equity	0.10	0.021
Inequality	0.00	0.103
Direct violence	NaN	0.042
Average (10)	0.475	0.236

Nota. † κ=1.00 sugiere que en las 3 encuestas el consenso humano e IA coincidieron exactamente en «convivencia pacífica». Con tan pocas unidades puede ser techo; léase como «coinciden en el patrón general» más que como «acuerdo perfecto estable».

On the other hand, Table 9 shows the overall results by model, including all three metaphors. Using Cohen's κ as the primary criterion and Krippendorff's α as a tiebreaker, the best model by item was: for Cooperation, GPT-5 Pro stood out (κ=.80; α=.613, higher than GPT-3 in α); in Antagonism, Gemini 2.5 Flash (κ=.67; α=.359); in Active Participation, DeepSeek (tie at κ=.67, tiebreaker by α=.302 versus GPT-5's α=.209); in Integrated Diversity, DeepSeek (κ=.64); in Segregation/Marginalization, GPT-5 Pro (κ=.27); in Hierarchical Power, GPT-5 Pro (tie in κ=.25, higher α=.254); in Peaceful Coexistence, DeepSeek (κ=1.00; probable ceiling effect with N=3); in Equity, GPT-5 Pro (tie in κ=.31, higher α=.094); in Inequality, GPT-5 Pro (κ=.21); and in Direct Violence, DeepSeek (only one with an estimate; κ≈0, α=.169). On average, DeepSeek obtained the highest κ (0.403) and GPT-5 Pro the highest α (0.282), but with a κ (0.388) similar to DeepSeek.

Table 9. Results of the agreement index by item, model vs. humans (Cohen's κ and Krippendorff's α, ordinal)

Ítem	**GPT 5 κ**	**GPT 5 α**	**GPT 5 Pro κ**	**GPT 5 Pro α**	**GPT o3 κ**	**GPT o3 α**	**DS κ**	**DS α**	**Gf κ**	**Gf α**
Cooperation	0.571	0.549	0.800	0.613	0.800	0.464	0.727	0.600	0.640	0.565
Antagonism	0.000	0.076	0.667	0.264	0.000	0.077	0.400	0.300	0.667	0.359
Active participation	0.667	0.209	0.625	0.296	0.625	0.246	0.667	0.302	0.595	0.355
Inclusive Diversity	0.545	0.315	0.571	0.495	0.571	0.401	0.640	0.172	0.400	0.332
Segregation/ marginalization	0.250	0.270	0.267	0.475	0.250	0.285	0.250	0.320	0.250	0.293
Hierarchical authority	0.250	0.140	0.250	0.254	0.250	0.179	0.250	0.150	0.000	-0.011
Peaceful coexistence	0.000	0.128	0.000	0.199	0.000	0.085	1.000†	0.306	0.400	0.208
Equity	0.308	0.067	0.100	0.064	0.308	0.094	0.100	0.072	-0.200	-0.049
Inequality	0.000	0.013	0.211	0.171	0.100	0.128	0.000	0.012	-0.200	-0.055
Direct violence	NaN	0.015	NaN	-0.009	NaN	-0.006	0.000	0.169	NaN	0.010
Promedio	0.288	0.178	0.388	0.282	0.323	0.195	0.403	0.240	0.283	0.201

Note. "GPT 5 κ/α" = Cohen's κ / Krippendorff's α (ordinal) for ChatGPT 5; "GPT 5 Pro κ/α" = κ/α for ChatGPT 5 Pro; "GPT o3 κ/α" = κ/α for ChatGPT o3; "DS κ/α" = κ/α for DeepSeek; "Gf κ/α" = κ/α of Gemini 2.5 Flash. κ reflects the model's agreement with the human consensus on a per-item basis (weighted for ordinal scales where applicable); α was estimated using all model runs against the human panel. In cases of tied κ values, the model with the higher α was considered "better." † A κ=1.00 with a low N may indicate a ceiling effect rather than robust agreement.

In the binary items designed to capture specific processes—scenes of violence containment (7.1), constructive conflict resolution (8.1), and conditions for lasting peace (9.1)—both the experts and the GAI models mostly responded with the "No" option (0). That is, in the three metaphors reviewed, there were insufficient indications in either the descriptions or the guided readings to affirmatively confirm the presence of containment mechanisms, resolution practices, or transformations toward peace (see Table 10). First, the low kappa values on these questions do not necessarily invalidate the instrument: rather, they indicate a lack of signal in the stimuli under the test conditions. Second, when attempting to assess reliability in the detection of infrequent processes (e.g., explicit containment actions), it is advisable to increase the number and diversity of stimuli or rebalance the categories to produce information interpretable by the agreement metrics. Furthermore, the closed-ended items in Table 10 were reviewed individually according to the models; there were no significant differences to report.

Table 10. Results for closed items.

Ítem	Escala	Fleiss' κ (multi-rater)	Cohen's κ (Consensus on H vs. GAI)	Krippendorff's α
3.1 Perception	ordinal	—	0.00	0.023
4. Division into subgroups	binary	0.014	0.00	0.024
7.1 Scenarios for violence containment	binary	−0.029	NaN	−0.018
8.1 Constructive resolution	binary	−0.001	NaN	0.010
9.1 Conditions for lasting peace	binary	0.095	0.00	0.105

3.3. Reliability of the judgment

As shown in Table 11, generalizability estimates provide a complementary and more stable perspective than Kappa coefficients when the number of stimuli is small or the sample is unbalanced. In the G-study, we calculated variance components and reliability coefficients for three panels: human (n=6), GAI (n=25), and mixed (n=31). The human panel showed moderate reliability (G ≈ 0.73; Phi ≈ 0.68) accompanied by a very high image × judge interaction (sigma2_pxr = 0.908). This interaction variance indicates that experts differ from one another in how they evaluate each metaphor; that is, the differences are not concentrated so much in the stimuli as in each judge's individual response to each image, a characteristic expected in interpretive tasks where professional subjectivity influences judgment.

In contrast, the GAI panel showed very high reliability (G ≈ 0.98; Phi ≈ 0.98), with low variance (σ^2_r ≈ 0.083) and lower residual variance; this means that the models reproduced criteria very consistently across runs. The mixed panel combined both properties, yielding an approximate G = 0.976 and an approximate Phi = 0.970: the combination of GAIs and expert humans produces very high reliability, suggesting that

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GAIs stabilize the overall score while human participation preserves the critical anchor for content validity. As for the model with the highest reliability under these conditions, ChatGPT 5 Pro achieved an approximate G of 0.98. In practical terms, the G-study shows that the inclusion of automated models reduces inter-rater variability and increases the reliability of the evaluation system, although the interpretation of specific cases still requires human oversight.

Table 11. G-study Results.

Panel/Model	n_judges	σ^2_p	σ^2_r	σ^2_p×r	G	Φ
Humans	6	0.404	0.214	0.908	0.728	0.684
GAI (global)	25	0.896	0.083	0.366	0.984	0.980
Mixed (humans and GAI systems)	31	0.719	0.128	0.553	0.976	0.970
ChatGPT 5	5	0.917	0.043	0.242	0.974	0.970
ChatGPT 5 Pro	5	1.160	0.010	0.120	0.980	0.978
ChatGPT o3	5	0.767	0.092	0.271	0.934	0.913
Deepseek	5	0.949	0.057	0.480	0.908	0.898
Gemini 2.5 Flash	5	1.216	0.000	0.310	0.951	0.951

Note. G = relative reliability (consistent ranking of objects); Φ = absolute reliability (absolute decisions); σ^2_p = variance among objects; σ^2_r = variance among judges; σ^2_p×r = object×judge interaction (and residual).

3.4. Ideal mix for human judging plus GAI

The D-study translates variance components into recommendations regarding how many human judges and GAI runs to include in order to achieve desired reliability thresholds. The results show that the largest increase in G occurs when incorporating GAI models: increasing the number of runs to 5–10 produces substantial increases in G, while adding more than 10–15 runs yields diminishing returns. Specifically, small combinations such as 1 human evaluator + 10 GAI runs already achieve an approximate G of 0.95 (approximate Phi of 0.94), and 1–2 humans + 15 GAI runs raise G above 0.96; on the other hand, panels with multiple humans but no GAI exhibit lower G values (for example, 2–4 human judges without AI do not reach those thresholds).

Table 12. G-theory D-study: Expected G and Φ values for H + GAI mixtures

H - GAI	0	5	10	15
1	—	0.888 / 0.866	0.950 / 0.939	0.968 / 0.962
2	0.449 / 0.416	0.870 / 0.845	0.942 / 0.930	0.964 / 0.957
3	0.560 / 0.514	0.864 / 0.838	0.936 / 0.922	0.961 / 0.953
4	0.632 / 0.585	0.863 / 0.836	0.933 / 0.919	0.959 / 0.950
6	0.728 / 0.684	0.870 / 0.845	0.931 / 0.916	0.955 / 0.946

Note: Cells = G / Φ. Bold text indicates G ≥ 0.94. Combinations not shown were estimated but are omitted for brevity.

Furthermore, when the number of GAI runs is 10 or more, adding more than 1–2 human evaluators does not increase reliability and may even slightly reduce it due to the increased inter-rater variance introduced by humans. The operational interpretation under these conditions is as follows: for institutional monitoring and scaling tasks, a compact mix—1–2 supervising human judges alongside approximately 10 GAI runs—offers a balance between cost and reliability.

Figure 3 depicts, via a heatmap, the expected G coefficient for different mixtures of human judges (H) and GAI models (A) in the panel. The horizontal axis shows the number of GAI runs (0, 5, 10, 15, 20, 25) and the vertical axis the number of humans (1–6). Lighter shades indicate higher reliability (G). With A=0, G increases with H but remains moderate: ≈0.45 (2H), ≈0.56 (3H), ≈0.63 (4H), ≈0.68 (5H), and ≈0.73 (6H). Case 1H+0A appears without an estimate (blank cell) because with a single judge, G is not defined for relative decisions.

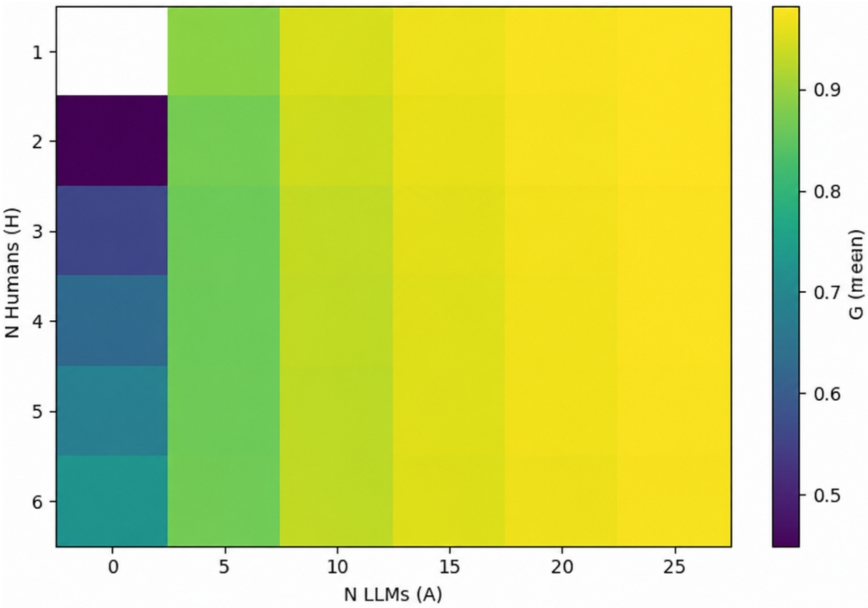

Figure 3. D-study results.

3.5. Top-performing LLM

The model ranking was constructed using a composite score that weights Kappa-Likert (70%), Kappa-binary (20%), and global index correlation (10%). Under this criterion, ChatGPT 5 Pro was the model closest to human consensus (approximate score = 0.975; approximate Kappa-Likert = 0.648; approximate Kappa-binary = 0.250), followed by ChatGPT o3 (approximate score = 0.725). This ranking should not be interpreted as universal "best performance," but rather as greater proximity to expert consensus on the three metaphors, given the versions and input conditions used in the study. The other models evaluated (ChatGPT 5, DeepSeek, Gemini 2.5 Flash) faithfully reproduced the overall order of the metaphors in the index (rho correlation = 1.00), although they exhibited lower Likert kappa; that is, they were less precise in the item-by-item details.

Table 13. LLM Rankings

LLM	κ-Likert	κ-Bin	ρ Índice	Score
ChatGPT 5 Pro	0.648	0.250	0.50	0.975
ChatGPT o3	0.629	0.111	0.50	0.725
ChatGPT 5	0.476	0.111	1.00	0.345
Deepseek	0.392	0.111	1.00	0.121
Gemini 2.5 Flash	0.384	0.111	1.00	0.100

4. Discussion and Conclusions

From the sociocultural framework of coexistence—which distinguishes between everyday interpersonal practices and institutional management (Fierro-Evans, 2013; Fierro-Evans & Carbajal-Padilla, 2019; Giddens, 1998; Weiss, 2015; Rodríguez-Figueroa, 2019, 2021)—the differences between experts and models are interpreted as distinct ways of working with the available evidence. The human interpretation was more contextual and holistic; that of the models, more standardized and dependent on explicit cues from the image or its textual description. When metaphors provided integrative clues—shared spaces, circulation, or visible links between groups—the human panel assigned higher coexistence scores, while the models produced more conservative scores. This contrast is consistent with the literature on the educational use of GAI: without guidance, LLMs can generate homogeneous responses or rely on superficial patterns; with clear direction, they can support processes of analysis and feedback (Zhai et al., 2024; Kosmyna et al., 2025; Nasr et al., 2025).

When comparing models, ChatGPT 5 Pro showed the highest overall alignment with human consensus. This advantage should be interpreted with caution because the ChatGPT variants used images and descriptions, while DeepSeek and Gemini relied on textual input. Therefore, the difference does not allow us to conclude that the model is generally superior, but rather that it is more closely aligned under the conditions of this study. In the case of DeepSeek, the matches were more visible in specific items, but not always in the overall magnitude of the index. This differential calibration aligns with studies on text evaluation where models replicate patterns but require explicit pedagogical anchors, supporting theory, and human review to sustain overall judgments (Bui & Barrot, 2025; Bouziane & Bouziane, 2024; Usher, 2025; Atasoy & Arani, 2025).

Differences among items on the Likert scale confirmed that the models align better with human behavior when the cues are observable. Agreement was high regarding visible behaviors (e.g., cooperation, antagonism, and participation). In contrast, alignment decreased when normative and subjective constructs (equity, inequality, hierarchical power) came into play: in those cases, human judgment provided contextual understanding, institutional histories, and attention to power relations that the models did not reproduce with the same precision. Therefore, LLMs perform best with clear, standardizable signals, but require blueprinting, specific grounding, and subsequent review to approximate evaluations that depend on notions such as justice and the distribution of opportunities (Doughty et al., 2024; Mistry et al., 2024; Scaria et al., 2024; Arif et al., 2024; May et al., 2025).

In terms of text production, all GAI systems wrote more than the experts, especially regarding interpretation and conflict. This finding is not interpreted as evidence of greater depth, but rather as a characteristic of text generation in response to open-ended prompts: the models tend to cover more points, add redundancies, and offer lengthy explanations. The experts, on the other hand, were more concise and focused their writing where it made sense to elaborate. Length can be useful if guided by specific prompts, clear rubrics, and length limits; otherwise, it can increase analytical noise. This precision directly addresses the need to distinguish between word count, depth, conciseness, text type, and argumentative quality (Kiryakova, 2025; Nasr et al., 2025).

Regarding reliability, the findings revealed a pattern: the GAI systems were highly consistent across runs; the human panel was more variable—as expected in interpretive tasks—and combining both sources increased stability without eliminating the contextual anchor of expert judgment. In practical terms, for monitoring, debugging, and exploratory studies, a small mix of people with a moderate number of GAI runs is recommended (for example, one to two experts with around ten runs of one or more models). For sensitive decisions, especially when equity, peace, or power relations are at stake, it is advisable to increase the weight of human judgment (Shavelson & Webb, 1991; Brennan, 2001; AERA, APA, & NCME, 2014).

4.1. Scope, limitations, and projections

This study should be viewed as a preliminary reference rather than a definitive assessment of GAI. Technology is evolving rapidly, and it is likely that more recent or future versions will improve direct image reading, multimodal reasoning, and pedagogical calibration. Precisely for this reason, the value of this work lies in providing a documented baseline: it shows what happens when experts and models are compared under explicit input conditions, how agreement varies across observable and normative dimensions, and which combinations of evaluators yield the highest reliability. These results are part of a potential set of investigations; in the future, deeper pedagogical analyses of student work could be conducted, updated multimodal models could be incorporated, more specific rubrics could be compared, and not only text length but also argumentative quality, interpretive depth, and usefulness for educational feedback could be evaluated.

In conclusion, and in response to the research objective, humans and GAI systems largely agreed on observable dimensions and differed more on normative and subjective dimensions. While this pattern might seem to be expected, its significance lies in having documented it empirically in a specific task involving the evaluation of visual metaphors related to school coexistence. Thus, what is seemingly obvious acquires scientific value when it is specified, measured, and situated within a specific empirical field. The human panel demonstrated a greater ability to contextualize concepts such as justice, equity, or power; the models produced more conservative scores when these constructs were not explicitly present in the image or description. ChatGPT 5 Pro was the system closest to human consensus under these conditions, while DeepSeek stood out on specific items. All the AI systems generated more text than the human panel, but this abundance should be understood as a stylistic trait rather than a direct measure of quality. The study's main contribution is methodological and pedagogical: it offers a framework for combining human judges and AIs, identifying the areas where automation can be helpful, and defining where expert interpretation remains essential—especially for future analyses of student work on school coexistence.

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ARTICLE / ARTÍCULO

Teacher training as a key factor in the adoption of artificial intelligence in primary education

La capacitación docente como factor clave en la adopción de inteligencia artificial en educación básica

Juan Miguel Albornoz-Pinilla

Abstract: Introduction/Objective: This study examines the relationship between formal artificial intelligence (AI) training and its adoption in teaching practice among primary education teachers in Chile's Maule Region, a territory marked by urban-rural inequalities. Method: A cross-sectional exploratory-descriptive contrasting-groups design was used with a sample of 150 teachers (54% women; 58.7% urban, 41.3% rural), who completed a validated 34-item questionnaire (August-October 2025). Descriptive statistics, Chi-square test, and Cramér's V as effect size measure were applied. Results: Complete group differentiation was observed ($\chi^2 = 143.96$, df = 1, $p < .001$; Cramér's V = 0.980): 100% of formally trained teachers (n = 31) actively use AI, while no untrained teacher (n = 119) has integrated it. Trained teachers show high-frequency use (90.3%), high confidence (67.7%), and perceived pedagogical improvements (100%). A descriptive pattern of territorial inequality in training access is observed (urban: 25.0% vs. rural: 14.5%; rate ratio = 1.72). Discussion/Conclusions: Findings challenge the teacher-resistance narrative (only 10.1% of untrained teachers express active opposition), pointing to predominantly structural barriers. Formal training emerges as an enabling condition for AI adoption, with direct implications for the design of territorial equity policies governing access to teacher professional development in Latin American contexts marked by urban-rural inequality.

Keywords: Artificial Intelligence, Elementary Secondary Education, Elementary School Teachers, Educational Technology, Territorial Inequality, Equal Education

Resumen: Introducción/Objetivo: Este estudio examina la relación entre capacitación formal en inteligencia artificial (IA) y su adopción pedagógica en docentes de educación básica de la Región del Maule, Chile, territorio con desigualdades urbano-rurales. Método: Diseño transversal exploratorio-descriptivo de grupos contrastantes con 150 docentes (54% mujeres; 58.7% urbanos, 41.3% rurales), quienes respondieron un cuestionario validado de 34 ítems (agosto-octubre 2025). Se aplicó estadística descriptiva, Chi-cuadrado y V de Cramer. Resultados: Se observó una separación prácticamente completa entre grupos ($\chi^2 = 143.96$, gl = 1, $p < .001$; V de Cramer = 0.980): el 100% de docentes capacitados (n = 31) usa IA activamente; ningún docente sin capacitación (n = 119) la ha integrado. Los capacitados presentan alta frecuencia de uso (90.3%), alta confianza (67.7%) y mejoras pedagógicas percibidas (100%). Se observa inequidad territorial descriptiva en el acceso a capacitación (urbano: 25.0% vs. rural: 14.5%; razón de tasas = 1.72). Discusión/Conclusiones: Los resultados cuestionan la narrativa de resistencia docente, pues solo el 10.1% de no capacitados expresa oposición, señalando barreras predominantemente estructurales. La capacitación formal emerge como factor diferenciador para la adopción de IA, con implicaciones directas para el diseño de políticas de equidad en el acceso al desarrollo profesional docente en contextos latinoamericanos con desigualdad territorial.

Palabras-clave: Inteligencia Artificial, Educación Básica, Docentes de Educación Primaria, Tecnología Educativa, Desigualdad territorial, Igualdad de oportunidades educativas.

1. Introduction

Chile has spent more than three decades investing in educational technology: since 1992, computer labs were built, digital platforms were deployed, and 96% of its schools were connected to the internet. In 2024, the vast majority of its primary education teachers do not use artificial intelligence in the classroom, a paradox that constitutes the starting point of this study, not because AI is a pedagogical obligation, but because the gap between available infrastructure and actual adoption reveals something about how teacher technology training policy works, or fails to work. Organizations such as UNESCO (2021) and the OECD (2023) have for years pointed out that the challenge is no longer access but training. The data from the Maule Region presented here confirm that reading with a force that is worth examining.

In Latin America, empirical research on AI adoption in primary education is significantly scarce. The systematic review by Zawacki-Richter et al. (2019) found that only 2.4% of studies on educational AI came from this region, evidencing a critical gap in the production of situated knowledge. Most of the available theoretical frameworks, such as the Technology Acceptance Model (TAM) by Davis (1989) or the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003), were developed in Global North contexts with consolidated digital infrastructure and articulated public policies, conditions that do not characterize Latin American education systems (CEPAL, 2021).

This study is situated in that gap, examining AI adoption among 150 primary education teachers in Chile's Maule Region. The territory concentrates significant inequalities between urban and rural areas: according to ministerial data (MINEDUC, 2023), 89% of urban schools report adequate connectivity compared to 54% in rural areas. This is not a technical problem; it is a structural condition that unequally distributes the possibilities for technological integration depending on where teaching takes place. This study examines what happens, in a specific territory with known structural inequalities, when a minority of teachers gain access to formal AI training and the majority do not. The guiding question and the specific objectives of the study are presented in the Methodology section, where they are articulated with the corresponding research design.

This study does not attempt to settle whether Chilean teachers should use AI or when they should do so. The question is more concrete: what happens, in a specific territory with known inequalities, when a minority of teachers receives formal training and the majority does not. That difference in starting point has consequences that the data allow us to observe with some clarity. The Maule Region is not a singular or peripheral case: its characteristics, consolidated educational infrastructure, persistent urban-rural gaps, insufficient and geographically concentrated continuing education offerings, are repeated with variations across much of the Latin American educational landscape.

1.1. Teacher technology adoption: from individualist models to structural approaches

For decades, research on technology adoption in education was dominated by a single question: why do some teachers use technology and others not? TAM (Davis, 1989) answered with two variables (perceived usefulness and ease of use) and that seemed sufficient. Venkatesh et al. (2003) expanded the model, but the logic remained individual: the teacher as the unit of analysis, their attitudes as the central variable. The problem with that view is not that it is incorrect, but that it is incomplete: Cuban (2001) was among the first to systematically document it, with schools of high computer availability and teachers who barely used them, not out of resistance or ignorance, but because institutional, curricular, and training conditions did not accompany the available technology.

What Cuban opened, others went on to confirm. Teacher training emerges in recent systematic reviews as the most robust predictor of effective technology adoption, above attitudes, pedagogical beliefs, or available infrastructure (Celik et al., 2022). This does not mean that individual variables do not matter: it means that without structural conditions to support them, positive attitudes toward technology rarely translate into real pedagogical use. A teacher convinced of AI's usefulness but without specific training is, in practice, in the same position as an indifferent one. The data from this study illustrate that dynamic with notable clarity.

Celik et al. (2022), in a systematic review of 100 empirical studies on educational AI, conclude that teacher professional development is the most influential and consistent factor for effective adoption, even above attitudinal and self-efficacy variables. Williamson and Eynon (2020) point in the same direction from another angle: AI integration policies tend to reproduce logics of individual accountability, expecting teachers to adopt emerging technologies without systematic investment in the conditions that would make that change possible.

For the Latin American context, the picture is no different. Martínez-Abad et al. (2020) and Pozos-Pérez and Tejada-Fernández (2018) document that limitations to adoption do not lie primarily in individual attitudes, but in structural inequalities of access to continuing education and in working conditions that restrict the time available for pedagogical experimentation. Rivas et al. (2023), in a prospective study with education and AI experts conducted for ProFuturo and the OEI, identified teacher training as the most highly valued priority for equitable AI integration in the region, above connectivity and tool availability, which coincides with CEPAL's (2021) diagnosis regarding access to continuing education as a persistent barrier in contexts with territorial inequality. In primary education specifically, Crompton et al. (2023) confirm in 66 empirical studies that teachers' use of AI is critically determined by access to professional training, and Yadav et al. (2024) document that this factor surpasses attitudes, self-efficacy, and technological access in predictive power.

1.2. Teacher training as a critical enabler for AI adoption

Speaking of teacher training in AI as if it were simply learning to operate tools falls short: Schön (1983) made this point decades ago, what forms a reflective professional is not the transfer of techniques but the construction of knowledge in practice, with real time, with mentorship, and with room to make mistakes. In emerging technologies such as AI, this requirement intensifies because the tools evolve faster than any training curriculum: what a teacher learns today about a specific model may be obsolete in six months. What does not become obsolete is the pedagogical judgment to evaluate and use them; a two-hour workshop on ChatGPT does not build that judgment: it may spark interest, but without sustained practice and mentorship, it rarely changes what happens in the classroom.

Cukurova et al. (2024), in a report for the European Commission, are explicit on this point: teacher professional development in AI requires continuous processes anchored in the institutional context and real pedagogical needs, not one-off events disconnected from practice. The distinction matters because it defines what can be expected from each type of intervention. A continuing training program with follow-up can change teaching practice; an isolated workshop, at best, generates favorable disposition without concrete pedagogical translation. When nearly four out of ten untrained teachers report knowing about AI applications but having had no opportunity to explore them, the diagnosis does not point to a lack of interest but to a training offer that does not reach them, or that reaches them insufficiently to become practice.

In the literature on teacher technology training, this structural perspective has gained increasing relevance. Romero et al. (2023), in a study with 667 Spanish primary, secondary, and university teachers, document that perceived digital competence is at an intermediate level across all experience brackets, and that the need for specific continuing training is transversal across the teaching profession regardless of gender or age. Méndez et al. (2022) add a relevant finding from initial training: prospective teachers perceive the competencies needed to integrate technology in a pedagogically meaningful way as insufficient, suggesting that training deficits do not begin in professional practice but earlier.

1.3. Structural barriers in Latin American contexts with territorial inequality

In Latin America, barriers to AI integration in education exceed individual attitudinal or competency-related dimensions. CEPAL (2021) identifies persistent territorial inequalities: while urban areas concentrate digital infrastructure and professional development opportunities, rural contexts face limited connectivity, lower access to training, and more precarious working conditions. The pattern is not new: it reproduces historical educational inequity logics that the emergence of AI may aggravate if specific policies do not intervene.

Chile's Maule Region constitutes a representative case of these patterns. With a population of approximately 1.3 million inhabitants distributed across 30 municipalities, it presents pronounced urban-rural gaps: 54% of rural schools report insufficient connectivity for digital pedagogical activities, compared to 11% in urban areas (MINEDUC, 2023). Teacher professional development in AI is geographically concentrated in provincial capitals, requiring costly travel for rural teachers; although the Center for Improvement, Experimentation, and Pedagogical Research (CPEIP), the agency of the Chilean Ministry of Education responsible for continuing teacher education, has promoted online formats to expand reach, coverage in rural areas remains insufficient relative to documented demand.

Maule is not an isolated case. Contexts such as Spain, with documented gaps between rural provinces and urban centers in access to continuing teacher technology training (Romero et al., 2023), or Latin American contexts such as Colombia, Peru, and Bolivia share similar structures. What occurs in a territory with consolidated infrastructure but unevenly distributed training matters beyond its borders: any system where teacher training in emerging technology is concentrated in urban centers faces variants of the same problem.

2. Methodology

2.1. Study design and scope

The guiding question of the study is: What differences exist between trained and untrained teachers in the integration of AI in primary education in Chile's Maule Region? The specific objectives are: (a) to characterize differences in effective AI use between the two groups; (b) to describe adoption patterns among trained teachers; (c) to identify the structural barriers perceived by untrained teachers; and (d) to examine contextual differences according to geographic location and type of school.

A cross-sectional exploratory-descriptive contrasting-groups design was used (Stebbins, 2001), aimed at identifying differential patterns between AI-trained and untrained teachers, and at characterizing the structural barriers perceived by the latter. This approach is appropriate given the emerging state of empirical research on AI adoption in Latin American primary education, where exploratory designs allow for the generation of hypotheses for future confirmatory research (Muñiz, 2018). The choice of a cross-sectional design responds to this exploratory logic: it constitutes a first systematic approximation to a phenomenon scarcely documented in the region, without any claim to capture the procedural dimension of adoption, which would require longitudinal designs in later research phases.

Inferences derived from this design are of contextual scope: the findings characterize patterns in the sample studied and should not be causally extrapolated to broader populations without additional longitudinal and quasi-experimental studies. This limitation is explicitly acknowledged and its implications are discussed in the conclusions.

2.2. Participants

The sample included 150 primary education teachers from the Maule Region, selected through convenience sampling with intentional heterogeneity criteria regarding geographic context and type of school. The gender distribution was 81 women (54.0%) and 69 men (46.0%). Teaching experience was heterogeneous: 28 participants with 1-5 years (18.7%), 37 with 6-10 years (24.7%), 34 with 11-15 years (22.7%), 29 with 16-20 years (19.3%), and 22 with more than 20 years (14.7%). Regarding administrative dependency, teachers participated from municipal schools (n = 81, 54.0%), municipal corporations (n = 35, 23.3%), subsidized private schools (n = 18, 12.0%), and foundations (n = 16, 10.7%). Regarding geographic context, 88 teachers (58.7%) work in urban areas and 62 (41.3%) in rural areas. The imbalance between the trained group (n = 31, 20.7%) and the untrained group (n = 119, 79.3%) is inherent to the contrasting-groups design and reflects the actual distribution of training in the territory studied; nonetheless, it has implications for the statistical power of the multivariate analyses specified in the Results section.

Table 1. Demographic and contextual characteristics of the sample (N = 150).

Variable	Category	n	%
Gender	Female	81	54.0
	Male	69	46.0
Teaching experience	1-5 years	28	18.7
	6-10 years	37	24.7
	11-15 years	34	22.7
	16-20 years	29	19.3
	More than 20 years	22	14.7
Type of school	Municipal	81	54.0
	Corporation	35	23.3
	Private	18	12.0
	Foundation	16	10.7
Geographic context	Urban	88	58.7
	Rural	62	41.3

2.3. Instrument

A structured 34-item questionnaire was designed, addressing: (a) demographic and contextual data; (b) participation in formal AI training; (c) patterns of AI use in teaching practice, frequency, nature, specific activities; (d) level of confidence and perceived improvements; and (e) perceived barriers to adoption and interest in future training. The question on AI use (item 12) explicitly asked about any type of use in the preceding three months, including experimental or sporadic uses, with the purpose of not restricting the response to consolidated uses.

A design limitation relevant to the interpretation of the main finding is the possible conceptual interdependence between the training item (item 8) and the AI-use item (item 12). Although both explore distinct dimensions, having received training versus having applied AI in teaching practice, it cannot be ruled out that, during the period studied (August-October 2025), formal training constituted the almost exclusive channel of access to AI in this context, which would explain the observed separation without necessarily implying that training is the direct cause of each instance of use. This distinction is relevant in order not to overinterpret the Cramér's V coefficient of 0.980 as causal evidence.

The instrument was validated through the judgment of five experts in educational technology, all with research experience in ICT integration in primary education, applying Lawshe's (1975) content validity procedure, which led to wording adjustments in 8 of the 34 items. Given the exploratory and multidimensional nature of the questionnaire, reliability was assessed through: (a) content validity with an expert panel; (b) piloting with 15 teachers not included in the final sample; and (c) for the prospective attitude toward AI subscale, the inter-item correlation ($r = .544$) and the Spearman-Brown coefficient ($\alpha = .704$) were calculated, a value considered adequate for exploratory instruments (Nunnally & Bernstein, 1994). The instrument was administered digitally via Google Forms between August and October 2025, with explicit informed consent and guarantees of confidentiality and anonymity.

2.4. Análisis de datos

Descriptive statistics were used to characterize the groups (frequencies, percentages, measures of central tendency). The association between formal training and AI use was analyzed using the Chi-square test with Yates' continuity correction, appropriate given that the 2×2 table presents cells with zero value, and Cramér's V as the effect size measure, considering values > 0.50 as a strong association (Cohen, 1988). This was complemented with Fisher's exact test. To examine whether secondary sociodemographic variables, gender, teaching experience, and type of school, moderate the relationship between training and adoption, a binary logistic regression analysis was performed. To examine territorial inequality in access to training, a Chi-square test of independence between training and geographic context was applied, complemented by the calculation of the urban/rural training rate ratio and the odds ratio. Open-ended responses on perceived barriers were categorized through deductive-inductive content analysis. Data were processed using SPSS v.28 and Microsoft Excel with a significance level of $\alpha = 0.05$.

2.5. Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human subjects. Voluntary participation was guaranteed through explicit informed consent, confidentiality of personal data, anonymity in reporting, and the right to withdraw without consequences. Data are stored with restricted access limited to the researcher and will be deleted after five years in accordance with institutional protocols.

3. Results

3.1. AI training and effective use: complete differentiation between groups

Only 31 teachers (20.7%) reported having received formal AI training applied to education, and 100% of this subgroup reported actively using AI in their teaching practice. In contrast, none of the 119 untrained teachers (79.3%) reported AI use in their pedagogical activities, even though the item explicitly explored experimental or sporadic uses in the preceding three months.

The Chi-square test with Yates' continuity correction revealed statistically significant differences ($\chi^2 = 143.96$, df = 1, $p < .001$). Fisher's exact test confirmed this result ($p < .001$). Cramér's V of 0.980 indicates a practically perfect association between both variables, configuring a categorical separation with no overlap: the group with formal training and the group without it represent completely differentiated adoption profiles in this specific context and moment.

It is important to note that the magnitude of this differentiation, higher than the typical ranges reported in technology-integration research where Cramér's V values of 0.30-0.50 already indicate moderate to large effects (Cohen, 1988), invites interpreting this result as an emerging contextual pattern. The separation may be partially influenced by the fact that the instrument explored use during a specific period (the preceding three months), which may not capture prior attempts at self-taught adoption.

Table 2. Differentiation in AI use according to formal training (N = 150).

Group	Uses IA	Does not use AI	Total
Trained	31 (100.0%)	0 (0.0%)	31 (20.7%)
Untrained	0 (0.0%)	119 (100.0%)	119 (79.3%)
Total	31 (20.7%)	119 (79.3%)	150 (100.0%)

Note. χ^2 = 143.96 (Yates correction), df = 1, p < .001; Fisher's exact test p < .001; Cramér's V = 0.980. The magnitude indicates practically complete differentiation between groups in this specific context and period.

3.2. Contextual profile of the groups

To verify that no sociodemographic variable moderates or confounds the main association, a binary logistic regression was performed including as predictors: formal training, gender, teaching experience (ordinal), type of school, and geographic context. The model presents a Nagelkerke pseudo R^2 of .988. In the multivariate model, only formal training was a statistically significant predictor (B = 9.03, OR = 8.321, p < .001); gender (OR = 0.65, p = .794), teaching experience (OR = 0.80, p = .745), type of school (OR = 0.92, p = .964), and geographic context (OR = 0.72, p = .853) did not reach statistical significance. These results should be interpreted with caution: the reduced size of the trained subgroup (n = 31) limits the statistical power of the model to detect real effects of secondary sociodemographic variables, so non-significance does not necessarily equate to the absence of effect.

Regarding the distribution of the trained subgroup by teaching-experience bracket, the 31 teachers are distributed as follows: 1-5 years (n = 4, 12.9%), 6-10 years (n = 4, 12.9%), 11-15 years (n = 9, 29.0%), 16-20 years (n = 8, 25.8%), and more than 20 years (n = 6, 19.4%). The distribution is relatively dispersed, with no extreme concentration in any bracket, which reduces the risk of instability in the logistic model's coefficients. A descriptive pattern of interest emerges when calculating training rates by bracket: teachers with 11-15 years (26.5%), 16-20 years (27.6%), and more than 20 years (27.3%) show notably higher rates than those with 1-5 years (14.3%) and 6-10 years (10.8%), suggesting that AI training is not concentrated among younger teachers but among those with greater professional trajectory. This pattern is consistent with the literature identifying professional experience as a predictive variable for participation in continuing training (Romero et al., 2023).

Table 3. Distribution of trained teachers by experience bracket and access indicators (n = 31).

Experience bracket	n trained	% within group	Training rate by bracket
1-5 years	4	12.9%	14.3%
6-10 years	4	12.9%	10.8%
11-15 years	9	29.0%	26.5%
16-20 years	8	25.8%	27.6%
More than 20 years	6	19.4%	27.3%
Total	31	100%	20.7%

Note. The Training rate by bracket column indicates the percentage of trained teachers out of the total number of teachers in that bracket in the sample (N = 150).

Analysis of contextual variables revealed differences in the geographic distribution of trained teachers. Among the 31 trained teachers, 22 (71.0%) work in urban contexts and 9 (29.0%) in rural contexts. Training rates are 25.0% among urban teachers (22/88) versus 14.5% among rural teachers (9/62), representing a rate ratio of

1.72 (urban teachers have a 72% higher probability of having received training than rural teachers). The Chi-square test of independence between training and geographic context did not reach statistical significance ($\chi^2 = 1.84$, df = 1, p = .175; Fisher's exact test: OR = 1.96, p = .152), which should be interpreted with caution given the reduced size of the trained subgroup (n = 31).

Regarding type of school, among trained teachers the municipal sector predominates (n = 20, 64.5%), followed by corporations (n = 5, 16.1%), private schools (n = 5, 16.1%), and foundations (n = 1, 3.2%). This distribution does not differ markedly from the overall sample, suggesting that administrative dependency is not a significant differentiating factor in access to training in this context.

Table 4. Contextual profile of trained and untrained teachers.

Variable	**Category**	**Trained (n=31)**	**Untrained (n=119)**	**Total (N=150)**
Geographic context	Urban	22 (71.0%)	66 (55.5%)	88 (58.7%)
	Rural	9 (29.0%)	53 (44.5%)	62 (41.3%)
Training rate		25% urban / 14.5% rural		
Type of school	Municipal	20 (64.5%)	61 (51.3%)	81 (54.0%)
	Corporation	5 (16.1%)	30 (25.2%)	35 (23.3%)
	Private	5 (16.1%)	13 (10.9%)	18 (12.0%)
	Foundation	1 (3.2%)	15 (12.6%)	16 (10.7%)

Note. Training rates calculated on the total number of urban (88) and rural (62) teachers respectively.

3.3. Adoption patterns among trained teachers (n = 31)

The data in this section correspond to a subgroup of 31 teachers and should be read as exploratory indications, not as a consolidated adoption profile. With that limitation in mind, what the data show is a trend toward regular use: 9 out of 10 trained teachers (90.3%) report daily or weekly use, suggesting that adoption, where it occurs, tends to be sustained over time rather than dissipating after training.

Regarding the nature of use, slightly more than half the subgroup combines stable use with experimental or mixed use, and the average number of pedagogical activities in which AI is used is 5.3 per teacher. The most frequent activity is the creation of educational materials, followed by lesson planning and activity design. Two out of three trained teachers describe themselves as confident or very confident in using AI, and the entire subgroup reported having observed some improvement in their pedagogical activities. These data, given the size of the subgroup, point to an integration that goes beyond immediate instrumental use, although its interpretive scope is necessarily limited.

Table 5. Summary of adoption patterns among trained teachers (n = 31).

Variable	Indicator	n	%
Frequency of use	Daily or several times/week	28	90.3
	Once/week or less	3	9.7
Nature of use	Stable use (regularly integrated)	13	41.9
	Experimental use (exploring)	10	32.3
	Mixed use	8	25.8
Activities (multiple responses; avg. 5.3/teacher)	Create educational materials	26	83.9
	Plan lessons and units	20	64.5
	Design activities and exercises	20	64.5
	Prepare presentations	18	58.1
	Create assessments and rubrics	18	58.1
	Search for information and resources	16	51.6
Level of confidence	Confident or very confident	21	67.7
	Moderately confident	7	22.6
	Not very confident	3	9.7
Perceived pedagogical improvements	Significant	15	48.4
	Moderate	16	51.6
	No improvements	0	0.0

Note. Activity percentages are calculated on n = 31.

3.4. Barriers perceived by untrained teachers (n = 119)

Among the 119 untrained teachers, six categories of barriers to AI adoption were identified. The most frequent was «lack of opportunity despite conceptual knowledge» (n = 47, 39.5%). The second was «unfamiliarity with specific pedagogical applications» (n = 31, 26.1%). Together, these two categories represent 65.6% of barriers, pointing to deficits in the professional development offering rather than negative individual attitudes.

Other barriers identified were: «tools not adapted to pedagogical needs» (n = 14, 11.8%); «unsatisfactory results in trial experiences» (n = 13, 10.9%); «preference for current methodologies without the need to incorporate AI» (n = 12, 10.1%); and «lack of clarity about what AI is» (n = 2, 1.7%). Only the 10.1%, the subgroup that prefers its current methodologies, could be interpreted as an expression of active resistance, while the remaining 89.9% faces barriers of a structural or training-related nature.

Table 6. Reasons for not using AI among untrained teachers (n = 119).

Main reason	n	%
I know about AI applications but have not had the opportunity to explore them	47	39.5
I understand what AI is but do not know specific applications in education	31	26.1
I have explored tools but they do not fit my pedagogical needs	14	11.8
I have tried tools but the results did not meet my expectations	13	10.9
I prefer my current methodologies without incorporating AI	12	10.1
I have no clarity about what Artificial Intelligence is	2	1.7

Nota. Categorías mutuamente excluyentes; cada docente seleccionó una razón principal.

3.5. Interest in future training

When asked about interest in receiving training in AI applied to education, the 119 untrained teachers responded: very interested (n = 58, 48.7%), interested (n = 37, 31.1%), moderately interested (n = 19, 16.0%), slightly interested (n = 4, 3.4%), and not interested at all (n = 1, 0.8%). Overall, 79.8% express high interest. The gap between this declared interest (79.8%) and actual access to training (20.7% of the total sample) evidences an unmet demand for professional development that current policies have failed to address.

4. Discussion

4.1. Training as a structural factor: scope and limitations of the finding

That 100% of trained teachers use AI and 0% of untrained teachers do is a result that somewhat unsettles anyone accustomed to reading educational research. Perfect effects almost never occur and, when they do, they must be examined carefully; the literature on teacher professional development in technology, Celik et al. (2022), Tammets and Ley (2023), and Cukurova et al. (2024), identifies training as the most influential factor in AI adoption, but none of those studies reports such complete separations. There are at least two non-exclusive explanations: a methodological one, related to the data-capture period and the possible interdependence between items; and a substantive one, related to the specific structural conditions of the Chilean context, where the AI training offer is so scarce that whoever accesses it represents an already actively motivated teacher profile.

The practically perfect differentiation may be partially explained by design features: the instrument captured use during the preceding three months, a period in which formal training availability was limited and recent for most participants. It is plausible that some untrained teachers had engaged in self-taught use attempts prior to or outside the studied period, not captured by the item. The absence of such self-taught adoption contrasts, on the other hand, with patterns observed in technologies of lower perceived complexity, reflecting the particularities of AI as a technology that requires a minimum training threshold for effective pedagogical use (Crompton & Burke, 2023).

Classic theoretical models, TAM (Davis, 1989) and UTAUT (Venkatesh et al., 2003), posit multiple concurrent variables: attitudes, pedagogical beliefs, self-efficacy, infrastructure. In this specific context, training emerges as the condition that marks the difference between users and non-users, displacing the rest. Romero et al. (2023) document something similar in Spain: even teachers with intermediate digital competence require focused continuing training to integrate emerging technologies. The European Commission (Cukurova et al., 2024) arrives at the same recommendation: teacher training in AI must be continuous, contextualized, and institutionally sustained.

4.2. Characteristics of pedagogically robust adoption

The adoption patterns observed among trained teachers suggest an integration that transcends superficial experimentation. 90.3% show high-frequency use, 41.9% have consolidated stable use, and the average of 5.3 pedagogical activities per teacher indicates versatility in appropriation. The most valued activity, the creation of educational materials (83.9%), is consistent with the priority teaching function and with prior research documenting this use as a preferred entry point for AI integration (Tammets & Ley, 2023).

The unanimity in the perception of pedagogical improvements (100%), although based on subjective self-assessment rather than objective measurements of student learning, is a relevant indicator of the perceived legitimacy of the technology among those who have adopted it. This pattern contrasts with evaluations of other educational innovations where greater heterogeneity of perceptions tends to emerge.

4.3. Territorial inequality and differential access to training

The difference in training rates between urban (25.0%) and rural (14.5%) teachers, with a rate ratio of 1.72, did not reach statistical significance in this sample ($\chi^2 = 1.84$, $p = .175$). This lack of significance should be interpreted with caution: the trained subgroup is small ($n = 31$) and the statistical power of the analysis is limited to detect real differences of this magnitude. A sample with at least 120 trained teachers would have sufficient power to test this hypothesis with confidence. Therefore, non-significance does not equate to absence of effect, but rather to insufficient evidence in the available sample.

Nonetheless, the direction and descriptive magnitude of the pattern are consistent with the frameworks of territorial inequality documented for Chile (MINEDUC, 2023) and for Latin America in general (CEPAL, 2021): rural teachers access professional development opportunities in technology in lower proportion, which, in a context where training is a necessary condition for adoption, has implications that go beyond technological access. If training operates as an enabler, the territorial gap in access to training translates into a gap in the quality of learning opportunities available to rural students.

4.4. Dismantling the teacher-resistance narrative

Only 10.1% of untrained teachers express a preference for their current methodologies without the need to incorporate AI, which could be interpreted as active resistance in Selwyn's (2019) sense. The remaining 89.9% face barriers of a structural or training-related nature: lack of training opportunities (39.5%), unfamiliarity with specific pedagogical applications (26.1%), perceived inadequacy of available tools (11.8%), or unsatisfactory initial experiences (10.9%). The declared interest in training (79.8% with high interest) reinforces this interpretation.

Williamson and Eynon (2020) had already pointed out the problem: narratives that individually hold teachers responsible for non-adoption of technology obscure the structural conditions that limit their possibilities for integration. Hence, strategies centered on attitudinal persuasion have little traction if they are not accompanied by investment in accessible training and institutional conditions that make change possible.

5. Conclusions

The data from this study say something that admits no nuance: in the Maule Region, no teacher without formal AI training uses it in their practice, and none with training fails to use it. Such a categorical separation, with Cramér's V = 0.980, is not common in educational research, and that warrants taking it seriously before relativizing it. The exploratory design and the convenience sample preclude causal generalizations, but the pattern is sufficiently clear to formulate three conclusions with direct implications for teacher training policy in Chile.

First, the practically complete separation between groups (Cramér's V = 0.980) indicates that, in this specific context and period, formal training emerges as the differentiating factor between adoption profiles. This association does not allow strict causality to be established given the cross-sectional design, but its magnitude and consistency point to training as a structurally relevant condition. Trained teachers show a robust adoption profile: high frequency of use (90.3%), wide diversity of pedagogical applications (average 5.3 activities), growing autonomous confidence (67.7%), and unanimous positive pedagogical valuation (100%).

Second, a significant territorial inequality persists: the training rate in urban contexts (25.0%) practically doubles the rural rate (14.5%), even though the overall distribution of the sample is more balanced. This gap is not merely a problem of technological access: it is a condition that reproduces and widens inequalities in the quality of teaching available to students depending on their territory.

Third, the teacher-resistance narrative finds no empirical support in this sample. 79.8% of untrained teachers express high interest in receiving training, and only 10.1% express a preference for not incorporating AI. The obstacles are predominantly structural, which directs policy design toward removing access barriers rather than toward persuasion or attitude-change strategies.

Chile has infrastructure. 95.2% of educational establishments have internet connectivity (MINEDUC, 2023). What it lacks, or has very unevenly, is accessible and territorially distributed teacher training in AI. The 79.8% of untrained teachers who declare high interest in training is not a minor finding in a system where the dominant narrative tends to attribute non-adoption of technology to teacher resistance or disinterest. That interest does not automatically translate into adoption; it needs to find a training offer that reaches teachers, that is continuous, and that considers the real conditions of both rural and urban teachers equally. As long as that offer does not exist or is insufficient, available infrastructure will remain a necessary but not sufficient condition for AI integration in Chilean classrooms.

Among the limitations of the study are its exploratory scope and cross-sectional design, which do not allow for establishing causality or temporal follow-up of adoption. The convenience sample limits the generalization of the findings beyond the context studied. The instrument did not include the variable of teacher age, which restricts the depth of the sociodemographic profile of the trained group; future research should incorporate both age and teaching experience to examine their differential contribution to AI adoption. Likewise, the lack of statistical significance of teaching experience in the logistic model should be interpreted with caution, as it may stem from statistical power limitations derived from the reduced size of the trained subgroup (n = 31) rather than from a real absence of effect. Future research should incorporate longitudinal and quasi-experimental designs that allow evaluation of the causal impact of specific training programs, objective measurements of student learning, and comparative analyses between regions with different levels of investment in teacher professional development.

The contribution of this study to existing knowledge can be articulated in three dimensions. In empirical terms, it provides contextualized evidence on a phenomenon scarcely documented in Latin American primary education, from a territory with characteristics replicable across multiple education systems in the region. In methodological terms, it validates an instrument adapted to contexts with territorial inequality, suitable for application in comparative studies between Latin American countries with similar structures. In terms of educational policy, it identifies a pattern of inequity in access to training that transcends the Chilean case: any system in which teacher training in emerging technology is geographically concentrated in urban centers faces variants of the same problem of inequity in the quality of learning opportunities available to students according to their territory.

6. Declaration on the use of artificial intelligence

During the preparation of this work, the author used generative artificial intelligence tools as support for stylistic review and improvement of academic writing. Data analysis, methodological design, interpretation of results, and conclusions are the exclusive responsibility of the author. The final content was fully reviewed and validated by the author.

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ARTICLE / ARTÍCULO

Digital Music Resources in Early Childhood Education: A Study of Spanish Repositories

Recursos digitales musicales en la educación infantil: estudio de repositorios españoles

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Abstract: Digital technologies have transformed educational environments, yet Early Childhood Education (ECE) remains an under-researched period regarding the use of technological resources, particularly in music. This study is part of an inter-university Research, Development, and Innovation (R&D&I) project and aims to analyse digital music resources targeting the second cycle of ECE available in Spanish institutional repositories: espazoAbalar (Galicia), Mestre@Casa and ReDi (Comunitat Valenciana), and EcoEscuela2.0 (Canary Islands). A descriptive methodology was employed based on the analysis of 643 digital resources. Of these, 37 were directly related to music education and examined according to five variables: prevalence, language, type, curriculum area, and target grade level. The results indicate that music resources account for only 5.75% of the total resources. Most resources are developed in Spanish or co-official languages, with Digital Learning Objects and online applications, tools, or platforms being the most common types. Nearly all are associated with the curriculum area of Communication and Representation of Reality and primarily target the entire second cycle of ECE. The study concludes that, despite institutional efforts, the digital music offer in ECE is limited, it lacks diversity and is unevenly distributed both linguistically and pedagogically. It is recommended to develop more multilingual resources, improve their classification, and promote their pedagogical evaluation to enhance their educational usefulness.

Keywords: Early childhood education, Music education, Instructional materials, Educational technology, Instructional design.

Resumen: Las tecnologías digitales han transformado los entornos educativos, pero la Educación Infantil (EI) continúa siendo una etapa poco investigada en relación con el uso de recursos tecnológicos, particularmente en música. Este estudio se enmarca en un proyecto de I+D+i interuniversitario y tiene como objetivo analizar los recursos digitales musicales destinados al segundo ciclo de EI disponibles en repositorios institucionales españoles: espazoAbalar (Galicia), Mestre@Casa y ReDi (Comunitat Valenciana), y EcoEscuela2.0 (Canarias). Se empleó una metodología descriptiva basada en el análisis de 643 recursos digitales. De estos, se identificaron 37 vinculados directamente a la educación musical, los cuales fueron examinados en función de cinco variables: presencia, lengua, tipo, área curricular y curso. Los resultados indican que los recursos musicales representan solo el 5.75% del total. La mayoría están elaborados en castellano o lenguas cooficiales, siendo predominantes los Objetos Digitales de Aprendizaje y las aplicaciones, herramientas o plataformas en línea. Casi todos se relacionan con el área de Comunicación y Representación de la Realidad y se dirigen principalmente al segundo ciclo completo de EI. Se concluye que, a pesar del esfuerzo institucional, la oferta musical digital en EI es escasa, poco diversificada y desigualmente distribuida lingüística y pedagógicamente. Se recomienda desarrollar más recursos multilingües, mejorar su clasificación y promover su evaluación pedagógica para fortalecer su utilidad didáctica.

Palabras-clave: Educación preescolar, Educación musical, Medios de enseñanza, Tecnología de la educación, Elaboración de medios de enseñanza.

1. Introduction

Digital technologies have transformed our world (Freitas de Torres, 2023; Saura and Caballero, 2021) across work, education, and even art itself. But in the education system, digitalisation has brought about a radical shift (Area-Moreira et al., 2020; Erwin and Mohammed, 2022; Navaridas-Nalda et al., 2020; Purnomo et al., 2024; Sosa and Valverde, 2020), leading teaching towards a distinctly hybrid scenario (Pardo et al., 2019).

The recent academic literature on this phenomenon is extensive. Still, the focus of observation tends to be on higher education, with little attention to Early Childhood Education (ECE), due to the controversies surrounding the issue. There is concern regarding the effects of overexposure to screens (Garavito-Sanabria et al., 2022; Gavoto et al., 2020; Priftis and Panagiotakos, 2023), and the underlying so-called 'digital dummy' (Ancajima, 2021). Conversely, other voices advocate for its introduction into nursery classrooms to counteract their adverse effects, enabling children to develop critical awareness through their didactic use (González, 2019). Thus, the educational process is aligned with current reality and childhood (Sevillano and Rodríguez, 2013), the 'digital native' generation (Prensky, 2011), although they lack the necessary skills to use them responsibly (Acosta, 2022).

Against this backdrop, this work stems from an inter-university Research, Development, and Innovation (R&D&I) project, focused on analysing the digitisation of the curriculum in the second cycle of ECE. Although ECE is not compulsory, it is the norm in Spain, with a net enrolment rate from age 3 of 97.2% (Ministry of Education and Vocational Training, 2022a). Specifically, this article examines the characteristics of digital music resources for this stage in three Spanish institutional repositories. Given that digital environments for music education present both advantages and obstacles (Freitas de Torres, 2023), their characteristics will lead to conclusions that can enhance their quality and guide their development.

Digital technology in children's music education has been scarcely explored in the academic literature (Cuervo et al., 2022). There are general studies on digital repositories, teaching practice, and the creation of Open Educational Resources (OER), such as that of Cohen, Kalimi, and Nachmias (2013). However, very few studies focus on music education (Allen, 2023), and even fewer examine music OERs created by students (Sliger et al., 2018). A review of three databases (Web of Science, Scopus and Google Scholar) using the keywords 'resources', 'repositories', 'early years' and 'music' in Spanish and English, yielded very few results. This contrasts with the growing interest in research on the creation and use of digital teaching resources (Area et al., 2022; Fernández et al., 2021; Marín et al., 2022). Regarding the specific topic at hand, digital music resources for ECE on repositories, only one study on repositories and music (see Pereira, 2019) and two on music and children were found. Firstly, although the digital ecosystem has undergone a metamorphosis (Area, 2017), the work of Vicente and Rodríguez (2014) lays the foundations for approaching the subject of this study. This work explores the educational provision and teachers' assessments of music teaching materials for ECE from a decade ago. Economic interests and publishers' proposals are the most influential factors in selecting and using these teaching materials, and the results highlight the need to improve teacher training in their selection. Secondly, Casal (2023) describes the digital teaching resources in the Galician repository espazoAbalar for the second cycle of ECE. This study concludes that not even one-tenth address musical content, and of these, only 22.3% are offered in Galician, with practically all being Digital Learning Objects (DLOs). As for the musical content, all resources focus on visual and auditory discrimination of instruments, except for one, which focuses on sound parameters.

Despite the scant coverage of digital music resources for ECE on repositories in recent literature, it warrants specific attention given the inherent particularities of music education in ECE. Unlike in later stages, music education is not recognised as a subject area (or sub-area) of the ECE curriculum but rather constitutes a basic skill: musical language and expression[1]. Added to this is the globalising nature of ECE, which is why music should be approached holistically. Consequently, its implementation in the classroom is largely carried out by generalists (Ivanova & Siebenaler, 2018) rather than specialists, which poses significant teaching challenges (Zamorano et al., 2022) in selecting and implementing resources.

To facilitate teaching, it is essential to have digital educational resources that present the content, skills, abilities, and attitudes of music education dynamically and straightforwardly, tailored to children's psycho-developmental characteristics. There are various ways to organise and present digital educational resources. Following Area (2017), we identify resources that are not specifically educational but are used in the classroom, such as digital objects (videos, presentations, etc.), applications, tools, and online platforms, as well as other resources with a clear educational purpose. These include digital textbooks, teaching didactic materials (created for teaching), digital learning objects (multimedia content for educational purposes), tangible teaching materials (online spaces designed to facilitate learning), and intelligent adaptive learning environments (linked to the use of Big Data in education). Studies such as the one by Becerra, Martín, and Bethencourt (2021) highlight the predominance of DLOs in ECE.

Amidst this variety, repositories have gained great importance as online spaces for storing, organising, and retrieving digital educational resources (Fernández-Pampillón et al., 2013; Sanabria et al., 2017; Santana et al., 2017). Public education authorities have devoted considerable effort to repositories (Gabarda et al., 2021), and there is currently a wide range of public repositories for digital educational resources. Offered by the Spanish autonomous regions, these include materials and sections specifically designed for the different educational stages. Regarding music education in ECE, these repositories can serve as an excellent resource for teachers. However, they also raise questions about how to ensure their proper implementation in the classroom and their suitability for supporting learning, given the scarcity of appropriate software for music education (Liao, 2022). Among these questions are: (1) What presence do the digital musical resources offered for the second cycle of ECE have in Spanish institutional repositories? (2) Given that ECE itself and multilingualism are policy priorities for the European Union (Birch, 2023; Council of Europe, 2019), in what language(s) are these resources designed?; (3) What types of resources are available?; (4) Which curriculum area are these resources in the repositories associated with?; and (5) Which school years do they target?

[1] Ministry of Education and Vocational Training (2022). Royal Decree 95/2022, of 1 February, establishing the organisation and minimum teaching requirements for Early Childhood Education. Official State Gazette, 28, 14561–14595. https://www.boe.es/buscar/act.php?id=BOE-A-2022-1654

Given the lack of specific studies, it is necessary to start with a preliminary descriptive analysis of their characteristics. In this paper, we will answer these questions.

2. Methodology

To address these questions, we have reviewed resources hosted in three institutional repositories, considering five nominal variables (Russell, 2018): presence, language, resource type, learning area, and school year. For the selection of the repositories, an intentional or deliberate selection (Patton, 2002) was made based on criteria previously defined for the research, established within the project in which this study is framed. Accordingly, the institutional repositories of digital educational resources from the three autonomous regions participating in the aforementioned project are available on the official websites of their respective regional governments: the Autonomous Community of Galicia, the Valencian Community, and the Autonomous Community of the Canary Islands.

2.1. Institutional digital repositories

Institutional digital educational resource repositories emerged in Spain in the early 2000s. Among the first was that of the National Centre for Information and Educational Communication (CNICE), which later became the Agrega Platform and marked the beginning of the platformization of the education system (Decuypere et al., 2021). Following the trail of this state impulse, the autonomous regions begin to offer their repositories.

Hosted by the Regional Department of Culture, Education and University espazoAbalar, the 'Repository of Educational Content' (Galician Regional Government) was born in 2010. Since its creation, it has amassed over 3,500 resources, although it has recently undergone a process of renewal and streamlining. Prior to this change, the platform allowed filtering by educational stage, but the current interface only offers three search options: language, resource type and licence. For the past few years, DIXIT, a parallel repository of innovative resources designed collaboratively by teachers that, in principle, puts students at the centre, has existed (Barreiro et al., 2023).

In the Valencian Community, the first institutional digital platform for educational functionality was Mestre@Casa, which comprised various sections, including an archive organised by educational stages. At each stage, the resources were classified by cycles, educational levels and learning areas or fields. Subsequently, in response to the need arising from the COVID-19 pandemic and the temporary transition to digital teaching, the Valencian Regional Government created a new repository: Rebost Digital (ReDi), which follows the same organisational structure as Mestre@Casa but with more up-to-date materials.

Under the Directorate-General for Planning, Innovation and Quality of the Government of the Canary Islands, EcoEscuela2.0 is the portal of the Autonomous Community of the Canary Islands. It offers various educational resources, classified into four categories: digital educational resources (with a variety of resources and interactive digital objects); media library (a space with images, videos, etc., mainly relating to the geography of the Canary Islands); CanariWiki (a collaborative website); and BioCan, the Canary Islands' natural inventory database.

2.2. Research phases

In accordance with the protocol of the Bioethics Committee of the lead university of the project, in an initial phase, a team of 12 people (4 per region) examined the preliminary characteristics of each institutional repository: espazoAbalar (Galicia), Mestre@Casa and ReDi–Rebost Digital (Valencia) and EcoEscuela2.0 (Canary Islands).

Subsequently, the resources targeting the second cycle of ECE (3-6 years) were classified and reviewed in each repository, using a matrix designed specifically for the research and validated by an expert group comprising four Spanish universities, an Ibero-American research group in didactics and school organisation, ECE teachers, and staff from the International Association for Research on Textbooks and Educational Media. The matrix included data on all digital resources available for the second cycle of ECE in each regional repository, yielding the following initial sample: 81 for Galicia; 284 for the Valencian Community (100 in Mestre@Casa and 184 in ReDi–Rebost Digital); and 278 for the Canary Islands, making a total of 643 initial resources reviewed.

In the second phase, the filters 'teaching' and subsequently 'early years education' of the Galician platform espazoAbalar were applied, which led to 81 resources. In line with the platform's data for each resource, these were all suitable for use across the entire stage (0-6 years), the second cycle (3-6 years), or specific years within the educational stage. Hence, all 81 were considered for the research. For the Valencian Community, the filters 'early years', and subsequently 'Second Cycle' of the platform Mestre@Casa were applied, yielding 100 educational resources. In ReDi, the stage (ECE) was selected, and the second cycle was subsequently manually chosen, resulting in a total of 184 resources. The Canary Islands portal EcoEscuela2.0 has three filtering sections: a search box (by keywords), a main menu (by educational stage and learning area), and a resource type (e.g., applications, videos, images, infographics). To identify resources for ECE, the simple search box was used with the keywords 'early childhood education' and 'early years', yielding 278 resources. Filtering by cycle was performed after identifying the resources linked to music education, as noted below.

As a result of the matrix, three tables were produced in the third phase of the research, containing the resources' data. Each resource was assigned a number and listed with its title, a direct link to the repository where it was hosted, and information such as the following:

- Language: Spanish, Galician and/or English for Galicia; Spanish, Valencian and/or English for the Valencian Community; and Spanish and/or English for the Canary Islands. These categories were not pre-established but emerged during the research. The research team also included the option 'various languages', which included resources that allow the user to choose the language from the options offered by the resource. This is the case of R3, which is in Galician and Spanish, or R25, which is in Spanish and Valencian (see Results and Table 2).

- Type: Digital Object (DO), Digital Learning Object (DLO), Digital Teaching Material (DTM), Professional Teaching Material (PTM), Applications, Tools or

Online Platforms (ATOPs), categories inspired by the classification established by Area (2017). These categories were included in the analysis matrix; that is, they did not emerge from the research but were pre-established before the resources were studied.

- Most relevant curriculum area: Growing up in Harmony, Discovery and Exploration of the Environment, and Communication and Representation of Reality (Ministerio de Educación y Formación Profesional, 2022b).
- Topic: key concepts regarding the content or topic of each resource (e.g., string instruments, auditory discrimination, etc.).
- School years/ages: the school years, ages, or cycles, as appropriate, for which the resource can be used were noted, based on the data or labels on the repositories.
- Other features: blank space to indicate, at the discretion of each researcher, notable characteristics of the resource (navigation, interactivity, type of tasks, inclusion or absence of feedback, interface design, etc.).

Finally, the fourth phase of the research involved collecting specific music education resources using data from the preliminary general matrices and the filtering options offered by each platform (see Table 1).

One person per region checked each resource to ensure that each one was directly related to the characteristics of basic knowledge F of Royal Decree 95/2022 (Ministerio de Educación y Formación Profesional, 2022b), called 'musical language and expression', particularly for repositories that did not offer the option to filter by 'music'. For Galicia, the preliminary matrix was used, which contained information on all available resources for ECE (n = 81), from which 9 were directly linked to music and extracted. As regards the Valencian context, to identify those addressing music education, each resource was accessed individually on Mestre@Casa, yielding 4 music education resources for ECE. For ReDi, music resources were found using the 'music' filter for ECE, yielding 13 resources from the 184 available at this stage. As this platform does not specify the cycle, the suitability for the second cycle was assessed individually, resulting in a total of 17 resources. For the Canary Islands, the search box on EcoEscuela2.0 was used with the following keywords and phrases: 'education' and `music' and 'early years', 'Early years education music' and 'Music in early years education'. The largest number of resources was returned by the phrase 'Early years education music', so we chose this option. Furthermore, the results provided by the other phrases and keywords duplicated those previously filtered. To ensure that the portal did not offer any further resources relevant to this research, a search using the section on the portal titled 'Languages, Communication and Representation» was also carried out, which led to the same results. This screening yielded 35 resources, which were reviewed individually using their tags to choose only those resources for the second cycle of ECE. Although these tags cannot be used as filters, they help distinguish the cycle; as a result, we obtained 11 music resources for the second cycle of ECE. Based on the overall filtering process for each region, the music resource data for ECE were compiled in a table (see Table 2), enhancing the data's readability and clarity (Russell, 2018).

Table 1. Steps followed to access the sample of digital music resources on the repositories.

Repositories	Sorted by cycle	Filter by music
espazoAbalar (Galicia)	N=81	(n=9): 9 resources out of 81 met the criteria for basic knowledge F of Royal Decree 95/2022.
Mestre@casa (Comunitat Valenciana)	N=100	(n=4): 4 out of 100 resources met the criteria for basic knowledge F of Royal Decree 95/2022.
ReDi (Comunitat Valenciana)	N=184	(n=13): 13 resources out of 184 met the criteria for basic knowledge F of Royal Decree 95/2022, and were listed in the repository under the tag «music».
EcoEscuela2.0 (Canarias)	N=35 35 resources out of 278 (all resources for the whole ECE) met the criteria for Basic Knowledge F of Royal Decree 95/2022, as identified through filtering with the phrase «Early Years Education music».	(n=11): 11 resources out of 278 met the criteria of basic knowledge F of Royal Decree 95/2022, the tag «Early Years Education music», and were indicated for the second cycle.

2.3. Description of the sample

As a result of the process described, a final sample of 37 digital music resources for the second cycle of ECE across the three regions was obtained: Galicia (n = 9), the Valencian Community (n = 17), and the Canary Islands (n = 11), as shown in Table 2. For each resource, the following details are included: a code (e.g., R1 = Resource 1), the language in which it is designed, the type of the resource (Digital Object -DO-, Digital Learning Object -DLO-, Digital Teaching Material -DTM-, Professional Teaching Material -PTM-, Applications, Tools or Online Platforms -ATOPs-), the most relevant curriculum area (CRR: Communication and Representation of Reality; and DEE: Discovery and Exploration of the Environment), and the school year/s in which each resource could be used. For the educational stages, we used ECE (Early Childhood Education), PE (Primary Education), CSE (Compulsory Secondary Education), and BAC (Baccalaureate).

For R26 (see Table 2), 'several languages' is indicated in the 'language' column and 'all ages' in the 'school years' column, as it can be used in English, Spanish, French, Portuguese, Russian and Chinese, and because the repository indicates that it targets «all ages». Despite its complexity, we decided to place it in the second cycle of ECE, as it holds IARC certification for early years and a PEGI Europe 3 rating (for ages 3 and older).

Table 2. Study sample: digital music resources for ECE children on espazoAbalar (Galicia), Mestre@casa and ReDi–Rebost Digital (Valencia), and EcoEscuela2.0 (Canary Islands).

Repository	Nº	Title	Language	Type	Area	School year
espazoAbalar (Galicia)	R1	O artista na aula e os nenos e nenas ao museo: Xaime Quessada (Workbook for the pupil)	Galician	DLO	CRR	6th ECE
	R2	O artista na aula e os nenos e nenas ao museo: Xaime Quessada (Workbook for the teacher)	Galician	PTM	CRR	6th ECE

Repository	Nº	Title	Language	Type	Area	School year
	R3	Vermes musicais	Galician & Spanish	DLO	CRR	6^{th} ECE
	R4	El mundo de Fantasmín	Spanish	DLO	CRR	4^{th} ECE
	R5	Así suenan los instrumentos	Spanish	DLO	CRR	1^{st} - 6^{th} ECE
	R6	Coloreamos instrumentos	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R7	Construimos nuestros propios instrumentos	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R8	Formemos una orquesta	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R9	Puzles de instrumentos	Spanish	DLO	CRR	1º-6º EI
Mestre@casa (R10-R13) y ReDi (R14-R26) (Comunitat Valenciana)	R10	Juega con los instrumentos musicales	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R11	Somos artistas	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R12	Cuento de los artistas	Spanish	DLO	CRR	4^{th} - 6^{th} ECE
	R13	Acudiu amb les guitarres	Valencian	DLO	CRR	4^{th} - 6^{th} ECE
	R14	La Factoria de Sons	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE
	R15	Trobadorets	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE
	R16	Correllengua 2020	Valencian	DLO	CRR	4^{th} - 6^{th} ECE
	R17	La Caixeta musical	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R18	Recursos AE Música i Arts Escèniques	Valencian	DLO	CRR	1^{st} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R19	Mainasons	Valencian	DLO	CRR	1^{st} - 6^{th} ECE
	R20	Rodamons teatre	Valencian	ATOP	DEE	1^{st} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R21	Canal de Dani Miquel	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R22	La música del Super3	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE
	R23	Les cançons de les feretes	Valencian		CRR	1^{st} - 6^{th} ECE
	R24	Els Bíters	Valencian	ATOP	CRR	1^{st} - 6^{th} ECE
	R25	La Colla i Acció	Valencian & Spanish	ATOP	CRR	1^{st} - 6^{th} ECE
	R26	Incredibox	Various languages	ATOP	CRR	All ages
EcoEscuela2.0 (Canarias)	R27	Güicho con las notas musicales	Spanish	DO	CRR	4^{th} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R28	Actividades de música para EI	Valencian	DLO	CRR	4^{th} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R29	Aprendomúsica	Spanish, German, English & Catalan	ATOP	CRR	4^{th} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R30	Sube y baja la marea	Spanish	DO	CRR	4^{th} - 6^{th} ECE & 1^{st} - 6^{th} PE
	R31	Toy Theater-Music	English	ATOP	CRR	4^{th} - 6^{th} ECE & 1^{st} - 6^{th} PE

Repository	Nº	Title	Language	Type	Area	School year
	R32	Tonematrix	English	DO	CRR	4th - 6th ECE, 1st -6th PE, CSE & BAC
	R33	Mi primer xilófono y piano – hecho para niños	Spanish	ATOP	CRR	4th - 6th ECE & 1st - 6th PE
	R34	Chrome Music Lab	English	ATOP	CRR	4th - 6th ECE, 1st -6th PE, CSE & BAC
	R35	Pito herreño	Spanish	DTM	CRR	4th - 6th ECE & 1st - 6th PE
	R36	Biblioteca de actividades JClic	English, Spanish & Catalan	ATOP	All	4th - 6th ECE & 1st - 6th PE
	R37	Cuentos y canciones con pictogramas	Spanish	ATOP	CRR	4th - 6th ECE & 1st - 6th PE

To ensure the replicability and validity of the study, the research team has faithfully adhered to the information in each resource on its platform when compiling Table 2. All data for the variables were extracted from the platforms, except for the type of resource and the learning area, which were determined by the research team for espazoAbalar and Mestre@Casa, as EcoEscuela2.0 and ReDi–Rebost Digital filter by learning area.

Data extraction took place between 2020 and 2025. As previously mentioned, during this period, the repositories underwent updates and remodelling, which explains why some resources are currently inactive. However, it is important to clarify that they were part of the repositories during the data collection period and may have been used by teachers. Therefore, all resources (those still available today and those no longer active but active in 2020) have been included in the sample. This provides a more accurate picture of the digital music resources available on the repositories over the last 5 years.

2.4. Analysis procedure

To describe the characteristics of the resources in terms of their presence (in relation to the total of resources from the three regions: N = 643), language, type, learning area and the school year they target, a quantitative-descriptive analysis was carried out on the 37 resources comprising the sample of the data shown in Table 2. The research team used Microsoft Excel to process the data and generate figures illustrating the results.

3. Results

The results outline the main characteristics of the digital resources based on five variables: a) the presence of digital music resources for the second cycle of ECE, b) languages, c) type, d) curriculum/learning areas, and e) the school years they target. They are presented in sections following the research questions.

3.1. What presence do the digital musical resources offered for the second cycle of ECE have in Spanish institutional repositories?

Thirty-seven out of 643 digital music resources for the second cycle of ECE in the institutional repositories of the autonomous regions were analysed, accounting for 5.75% of all resources targeting this cycle.

3.2. In what language(s) are they designed?

As shown in Figure 1, digital music resources targeting the second cycle of ECE are mainly produced solely in Spanish (37.84%), in a similar proportion to those designed in the co-official languages covered by the study (Valencian and Galician, 40.55%), or exclusively in foreign languages (English, 8.11%). Very few (13.51%) offer a multilingual option, and those that do always include Spanish. Regarding resources published entirely in co-official languages, the reach is much greater in Valencian (13 out of 17) than in Galician (2 out of 9), representing 76.47% and 22.22%, respectively.

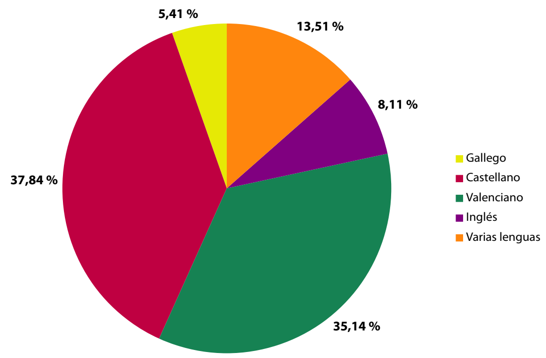

Figure 1. Languages of digital music resources for the second cycle of ECE in the Galician, Valencian and Canarian institutional repositories.

3.3. What types of resources are available?

Almost half (45.95%) of the available resources are ATOPs, closely followed by DLOs (40.54%). In much smaller proportions, DOs (8.11%), DTMs and PTMs (both 2.70%) can be found.

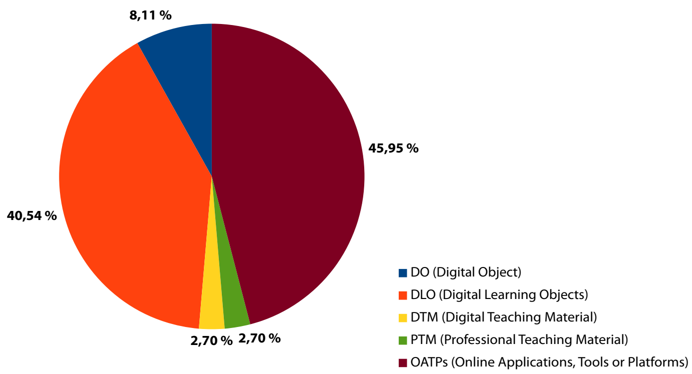

Figure 2. Types of digital music resources for the second cycle of ECE on the Galician, Valencian and Canarian institutional repositories.

3.4. Which curriculum area are these resources on the repositories associated with?

According to Table 2, all music educational resources for the second cycle of ECE are mainly linked to the curriculum area Communication and Representation of Reality. The uniqueness of the two resources is worth noting. R36 is a library encompassing various resources, which has led us to identify the three curriculum areas as linked to this resource, with no clear preference among them. Secondly, the researcher who analysed R20 indicates that it is a «workshop» for making musical instruments from recycled materials, which is why she decided to classify it as more directly linked to the area of Discovery and Exploration of the Environment.

3.5. Which school years do they target?

Figure 3 shows that more than half (54.05%) are aimed entirely at the second cycle of ECE, that is, from 4th to 6th grade of ECE (3-6 years). The resources indicated as suitable for use throughout the ECE stage, from 1st to 6th grade, account for 35.14% of the total. Very low percentages are indicated exclusively for the 6th grade (8.11%) and the 4th grade (2.70%).

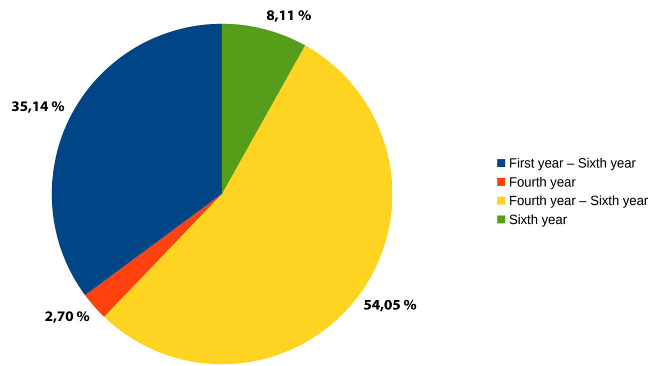

Figure 3. School years targeted by digital music resources for the second cycle of ECE on the Galician, Valencian and Canarian institutional repositories

4. Discussion

We have observed that the educational portals of the Spanish autonomous regions studied in this research offer a variety of digital resources. This implies considerable effort to maintain an active space, consistent with the work of Gabarda et al. (2021) on public investment by administrations in these resources. However, we note the low representation of digital music resources, which account for only 5.75% of the total resources allocated to the second cycle of ECE.

This could be linked to the scarcity of academic literature on this subject, as mentioned in the introduction to this text, given the lack of studies on this topic and this educational stage, the least researched in the national context. As noted, this could be due to the harmful effects of screens in early childhood, particularly overexposure

(Garavito-Sanabria et al., 2022; Gavoto et al., 2020). Hence, experts nowadays even refer to zero screens in early childhood. An example of this claim is the report of the committee of experts for the development of a safe digital environment for youth and childhood[2]. This report recommends no exposure to digital devices between ages 0 and 3, warns against their use until age 6, and limits their use to specific instances to maintain social contact, always under parental supervision. The report even suggests restricting adults' device use when children under 6 are present. In line with these arguments, the Spanish Paediatric Association (Asociación Española de Pediatría, 2024) advocates no screen time until age 6 and only 1 hour per day between ages 6 and 12. These concerns have recently been endorsed by law with the emergence of a new draft bill on the protection of minors in the digital environment in Spain[3], which also recommends avoiding screen use until age 6.

Although the use of technology in music education appears to be effective, with positive results in both musical and non-musical learning (Cuervo et al., 2022), the fact that music as a discipline is undervalued in schools «ultimately results in a scarce presence of digital educational resources for the field of music education» (Pereira, 2019, p. 81) on repositories. In addition, given the limited number of hours generally devoted to music in schools, we need to assess the appropriateness of using digital music resources.

This study concludes that there is practically the same representation of resources produced solely in the official language as of those designed in co-official languages, with a higher proportion of the latter in the Valencian Community than in Galicia. This could be linked to the language policies implemented or to the political instrumentalisation of co-official languages. The Valencian context highlights the promotion of the co-official language over the last decade carried out by teaching staff and the Botànic Education Authority, as reflected in the range of resources available on this region's repositories. In the Galician context, the prevalence of resources in the co-official language is more modest. Malheiro (2022) describes the de-Galicianization currently affecting Galicia and proposes following the models applied in other regions to «halt and even reverse the decline of a marginalised, slowly agonising heritage, as can be seen at present in Galician language» (pp. 129–130). Whilst European policies highlight multilingualism and ECE itself as priorities (Cortina-Pérez, 2022), we have also found that very few resources are designed directly in foreign languages or offered as multilingual options. Hence, the creation of more multilingual resources is necessary.

Concerning the types of resources, a high percentage (86%) are Applications, Tools or Online Platforms (ATOPs) and Digital Learning Objects (DLOs). This is in line with the preeminence of DLOs highlighted in Casal's (2023) research on music resources and with the generalist study by Becerra, Martín and Bethencourt (2021). However, the latter points to an evolution towards the proliferation of online platforms, which may be a consequence of the considerable supply and impact of entities that design and create digital educational materials, thereby favouring platforms.

[2] Spanish Ministry of Youth and Children. (2024). *Report of the committee of experts for the development of a safe digital environment for youth and children.* https://bit.ly/435syhE

[3] Government of Spain. (2024). Preliminary Draft Organic Law for the Protection of Minors in Digital Environments. Ministry of the Presidency, Justice and Relations with the Cortes; Ministry of Youth and Children; Ministry for Digital Transformation and the Civil Service; Ministry of Social Rights, Consumer Affairs and 2030 Agenda. https://bit.ly/4vnTghB

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About the curriculum areas, there is a wide range of resources linked to the area of Communication and Representation of Reality. This is consistent with the analysis by Casal (2023) and with the provisions of Royal Decree 95/2022 on musical language, which facilitates intercommunication and active listening (Ministerio de Educación y Formación Profesional, 2022b).

More than half of the resources studied target the entire second cycle (3-6 years), without specifying a school year, and almost 36% target the entire stage (0–6 years). Still, very few resources are designed exclusively for a specific school year. The speed that characterises educational digitalisation (Erwin & Mohammed, 2022; Purnomo et al., 2024) is unmanageable in real time for teachers, so repositories should facilitate their work. For this purpose, it is advisable to have a more balanced classification by school year to facilitate their selection. In line with the needs identified by Vicente and Rodríguez (2014), teachers intuitively select resources without reference points (such as assessment guides), which is related to a lack of both initial and continuous training. Both are highly influential in teaching practice with Information and Communication Technology (ICT) because they involve the internalisation of attitudes and habits that determine how technology is used. In addition, the provision of ICT training for teachers by the education authorities is scarce and highly instrumentalist (Sosa & Valverde, 2022). Particularly striking is the information in the 'grades' (school year/s) column in some of the resources (see Table 2: as stated in the platform's own information, R17 can be used during all the stages of ECE and Primary Education, while R26 can be used at all ages). This points to two aspects of interest. Firstly, it is necessary to highlight the generic nature of some resources: whilst they are clearly musical, some are videos or links to musical artists' channels and are therefore suitable for implementation at any educational level or stage. This leads to the second aspect: the prioritisation of quantity (Gabarda et al., 2021) over selection rigour, causing the entertainment factor to take precedence over educational and musical values. Whilst playfulness facilitates learning and appeals to digitally native generations (Paule-Ruiz et al., 2016), these resources should not neglect the educational and musical aspect that defines them. Without questioning the quality, this highlights the lack of evaluation and of specific, comprehensive criteria focused on the musical potential of the resources. The inclusion of guidelines for their didactic use beyond mere viewing or entertainment would reinforce this aspect.

5. Conclusions

Despite public investment in the creation and maintenance of institutional repositories containing digital educational content, music education resources for the second cycle of ECE hosted on these repositories are scarce, accounting for less than 6% of the total resources for that stage. These are offered in both Spanish and the co-official languages in roughly the same proportions, with the co-official figure considerably higher in the Valencian Community than in Galicia. Almost 90% are apps, platforms, or digital learning objects, and they cover content in the Communication and Representation of Reality curriculum area. More than half target equally pupils in 4th grade to 6th grade of ECE (3-6 years), and almost 40% target the entire stage (0–6 years), while those designed exclusively for a given grade are insignificant.

Among the weaknesses of this work, we highlight the continuous evolution of repositories, which means the available resources are constantly changing due to updates. Another area for improvement is the expansion of the autonomous communities analysed. Although the chosen communities were defined by the R&D&I project within which this article is framed, a possible future line of research could be to replicate this study in other regions to obtain a more comprehensive overview of the issue. Given the rapid pace of curriculum digitisation, it would be advisable to repeat the study over five years to examine the evolution of both the resources and the platforms that host them, as well as other variables such as their efficiency, quality, practical use, or even to carry out comparative analyses between different countries. Therefore, it is necessary to continue developing analyses such as the one presented here to optimise the pedagogical characteristics of the resources and to provide guidelines for their proper selection based on critical assessments of their potential.

6. Contribution of the authors

All authors contributed to the research and writing – draft, review and editing. Specifically: Conceptualisation (LCF, MIPB, CJGR); Methodology (LCF, MIPB, CJGR), Validation and Formal Analysis (LCF and MCPG), Visualisation (LCF).

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ARTICLE / ARTÍCULO

Video games in secondary education students: a psychosocio-educational perspective

Videojuegos en alumnado de educación secundaria: una perspectiva psicosocio-educativa

Adoración Díaz-López

Abstract: Problematic video game use is one of the main educational and social concerns today, especially during adolescence, a stage in which digital technologies play a central role in leisure, socialisation and everyday life. This study analyses various indicators associated with problematic video game use among secondary education students, focusing on its possible academic, psychological and social implications. The objectives of the study were to identify behaviours that indicate problematic video game use; to analyse the relationship between frequency of use and these indicators; to examine the association between these behaviours and technological stress; and to explore the relationship between gaming frequency and social skills. The sample consisted of 1,101 adolescents. The results show that 24.4% of young people acknowledge abandoning, interrupting or neglecting school duties in order to spend more time playing video games. Likewise, a higher frequency of use is associated with greater irritability when gaming is interrupted, a greater need to increase gaming time and more interference in daily life. An association is also identified between indicators of problematic use and technological stress. Finally, students who make more intensive use of video game consoles show lower assertiveness, a greater preference for virtual interaction and a stronger tendency to reduce face-to-face social activities.

Keywords: Video Games; Adolescents; Secondary School Students; Technology Uses In Education; Stress Variables; Social Skills; Behavior Problems.

Resumen: El uso problemático de videojuegos constituye una de las principales preocupaciones educativas y sociales actuales, especialmente durante la adolescencia, etapa en la que las tecnologías digitales ocupan un lugar central en el ocio, la socialización y la vida cotidiana. Esta investigación analiza diversos indicadores asociados al uso problemático de videojuegos en alumnado de Educación Secundaria, atendiendo a sus posibles implicaciones académicas, psicológicas y sociales. Los objetivos del estudio fueron identificar comportamientos que evidencien un uso problemático de videojuegos; analizar la relación entre la frecuencia de uso y dichos indicadores; estudiar la asociación entre estos comportamientos y el estrés tecnológico; y examinar la relación entre la frecuencia de juego y las habilidades sociales. La muestra estuvo compuesta por 1.101 adolescentes. Los resultados muestran que el 24,4% de los jóvenes reconoce abandonar, interrumpir o descuidar obligaciones escolares por pasar más tiempo jugando. Asimismo, se observa que una mayor frecuencia de uso se relaciona con más irritabilidad ante la interrupción del juego, mayor necesidad de aumentar el tiempo de juego y más interferencias en la vida diaria. También se identifica una asociación entre los indicadores de uso problemático y el estrés tecnológico. Finalmente, los estudiantes que hacen un uso más acusado de la videoconsola presentan menor asertividad, una mayor preferencia por la interacción virtual y una tendencia superior a reducir actividades sociales presenciales.

Palabras-clave: Videojuegos, Adolescentes, Estudiantes de secundaria, Uso educativo de la tecnología, Estrés, Habilidades sociales, Conducta problemática.

1. Introduction

Young people in today's society belong to the so-called Generation Z, the first generation born in the 21st century, fully immersed in technology. Taking society as the shaper of identity, these young people have grown up with different conceptions of time and space, immersed in immediacy and the chaotic evolution of the present day (Vázquez & Mouján, 2016). Adolescents of Generation Z incorporate ICT as another element in their learning and socialisation process (Urosa, 2015). Furthermore, they spend a large part of their time in cyberspace, where, within a multisensory virtual environment, they relate to and interact with one another, exchange information, communicate with peers, interact with strangers, make new friends, and have fun playing games. Nevertheless, it is indisputable that ICT has become an indispensable resource in the daily lives of young people. According to the latest data issued by the INE (2021) in Spain, 96% of 15-year-old adolescents have access to the Internet and 99% report using it for an average of more than 3 hours a day (Díaz-Vicario et al., 2019).

Although Internet and ICT use is widespread among people regardless of age, their most striking influence is found among the younger population. The health crisis caused by COVID-19 has only accentuated technology consumption figures among young people. These devices have become indispensable for communicating with peers, engaging with the world, and continuing their academic education (Montaña-Blasco et al., 2020). This context of high technological exposure creates a favourable scenario for analysing not only the opportunities, but also the risks associated with the intensive use of ICT during adolescence.

1.1. Problematic ICT and Video Game Use

In the new emerging social context, the use and development of ICT by adolescents implies new opportunities for their growth, autonomy, development, and personal education, but also the possible emergence of new risks associated with dysfunctional use (Díaz-López et al., 2020; Rodríguez-Rodríguez & García-Padilla, 2021; Montag & Hegelich, 2020). Problematic ICT use is defined as those behaviours related to neglecting family, educational, or social responsibilities in order to spend more time on the Internet and playing video games, reduced academic performance, preferring virtual relationships over real ones, showing restlessness when not receiving messages or calls, sleep disturbances due to mobile phone use, aggressiveness or irritation when interrupted while using devices, etc. (Díaz-López et al., 2020). Following the approach of Polo and Vargas (2024), adolescents constitute a risk group for the development of behaviours compatible with ICT addiction, as they are constantly seeking new sensations and, given their characteristics, represent a particularly vulnerable population (Aznar et al., 2020; González-Álvarez et al., 2025).

1.2. Consequences of Problematic Video Game Use

The literature has identified various consequences associated with problematic video game use, which can be grouped into the academic, psychological, and social domains. One of the main sources of concern is the enormous amount of time that young people spend immersed in ICT, as if absorbed by screens, devoting hours and hours of their time to them (Díaz-Vicario et al., 2019; Aznar et al., 2020). However, if there has been one controversy that has had a major impact over recent years, it has been the one concerning problematic video game use and the growing demands from the scientific and healthcare communities to have this activity classified as a mental disorder.

In this regard, it seems that the scientific evidence accumulated over the last decade, together with the pressure exerted by associations such as the American Medical Association, which advocates including video game use as a subtype of addictive disorder (Lloret et al., 2017), led the WHO to officially recognise video game addiction as a mental disorder at the end of 2019 (Arroyo, 2019), under the name Gaming disorder, with clinical implementation beginning in 2022. Furthermore, the new regional addiction plan for the period 2019–2024 incorporated online video game dependence into the DSM-5, as certain gaming behaviours stimulate reward systems similar to those activated by drugs, producing behavioural symptoms comparable to those caused by substances (Sánchez-Domínguez et al., 2021; Carbonell, 2020; Delgado, 2026).

In the present study, this issue was addressed from the perspective of problematic use, without assessing whether or not it constitutes an addiction. In this regard, problematic use is defined as actions related to neglecting family, educational, or social obligations in order to spend more time on the Internet and playing video games; reduced academic performance; a preference for virtual relationships over face-to-face relationships; sleep disturbances; and aggressiveness or irritation when interrupted while playing (Díaz-López et al., 2020). For this reason, video games are one of the main forms of entertainment in contemporary society and, moreover, constitute the preferred leisure activity among young people. Accordingly, the prevalence of problematic video game use in representative samples ranges from 1.2% to 8.5% (Griffiths et al., 2016). It should be noted that, although electronic devices do not in themselves pose a potential danger, the almost uninterrupted use of ICTs may interfere with the normal development of adolescents' daily lives.

In this respect, Díaz-López (2021) establishes a relationship between a high frequency of video game use and a decline in academic performance. Gómez-Gonzalvo et al. (2020), for their part, identify descriptive indicators of psychological pathologies, such as depression or anxiety, in the problematic use of video game consoles. Along these lines, Díaz-López et al. (2020) found statistically significant associations between the frequency of video game use and technostress. Similarly, a recent review study reports that problematic video game use is associated with higher levels of long-term stress (Pallavici et al., 2022).

With regard to adolescents' social sphere, a particularly concerning issue is the transformation that social relationships have undergone. In this respect, Sánchez-Díaz de Mera and Lázaro-Cayuso (2017) point out that the use of technology has modified the way individuals communicate with others, and they maintain that ICTs occupy an almost central role in the socialization process, influencing the behaviours and attitudes of younger people (García-Oliva et al., 2017; Gracia-Granados et al., 2020). Furthermore, Puerta-Cortés and Carbonell (2014) warn that ICT use displaces the time young people spend in the "real" world, redirecting it towards the "virtual" world. Díaz-Vicario et al. (2019) and Romero (2025) likewise indicate that extensive ICT use may lead to a deterioration in social skills, which may in turn result in a decline in social relationships. Previous studies on this topic reveal that almost 5% of students report having reduced the time they spend with their friends because of ICTs (García et al., 2014). Viñals and Cuenca (2016), for their part, presented findings from their qualitative study in which young people highlighted the existence of substantial differences between face-to-face and virtual communication.

1.3. Justification of the study

Despite the growing interest in video game use, evidence regarding its negative impact on social skills remains limited, which justifies the need to explore this relationship further. The most recent publications focus on analysing video game use and its contribution to the development of social skills (Molano & Suárez, 2022). However, there is little literature analysing the negative impact that problematic video game use has on social skills.

Based on this premise, four specific objectives were established: 1) To describe behaviours indicating psychologically based problematic video game use. 2) To analyse the relationship between the frequency of video game use and indicators of problematic video game use. 3) To analyse the relationship between indicators of problematic video game use and technological stress. 4) To analyse the frequency of video game use and its impact through its association with social skills.

2. Methodology

The research design was a quantitative non-experimental survey study. A cross-sectional design was used; therefore, the study focused its analysis on a specific point in time (Sáez-López, 2017). The sample consisted of a total of 1,101 participants, of whom 47.8% were boys and 52.2% were girls, enrolled in 1st year of compulsory secondary education (32.4%), 2nd year (22.3%), 3rd year (24.3%), and 4th year (21%), aged between 11 and 18 years (17% aged between 11 and 12 years, 46.1% between 13 and 14 years, and 36.2% between 15 and 18 years). This sample, representative at the 95% confidence level with a maximum estimation error of 5%, was obtained through a probabilistic sampling process by selecting 10 public schools from the nine districts that make up the Region of Murcia. The inclusion criteria were as follows: adolescents enrolled in 1st, 2nd, 3rd, and 4th year of compulsory secondary education (ESO) attending the ten selected schools. It was not necessary to establish exclusion criteria due to the nature of the study (Otzen & Manterola, 2017).

2.1. Instrument

The Ud-TIC questionnaire (Maladaptive Use of ICT) ($\alpha = .841$) (Díaz-López et al., 2022) was used. The instrument consists of:

- Sociodemographic data: This section comprises seventeen questions regarding personal information (age, sex, school year, and region). Attitude towards studying and ICT interference with studying (three items; 5-point Likert scale). Family supervision of Internet and social network use (1 item; dichotomous response). Adult responsible for supervision (1 item; polytomous response). ICT access schedule (1 item; polytomous response). Technological stress (1 item; dichotomous response).

- Problematic ICT use: This section consists of nineteen items, three of which are related to the frequency of use of video games (1. Never; 2. Almost never; 3.

Only at weekends; 4. Several times a week; 5. Every day), mobile phones (1. Never; 2. Only when I need it; 3. Frequently; 4. A lot; 5. At all times), and other Internet-connected devices (1. Never; 2. Only when I need them; 3. Frequently; 4. A lot; 5. At all times). The remaining sixteen items assess experiences related to the problematic use of mobile phones, the Internet, and video games (5-point Likert scale: 1. Never; 2. Sometimes; 3. Almost always; 4. Quite often; 5. Always). However, for the purposes of this study, only those items related to experiences associated with problematic video game use were analysed.

2.2. Procedure

An informed consent document was provided, and authorisation was requested from each participant's parents or legal guardians. Students were provided with an informed assent document explaining the anonymous and voluntary nature of their participation. Both documents were previously approved by the Research Ethics Committee of the University of Murcia. The instrument was administered in paper format. Data collection took place during tutorial periods and in the presence of the class tutor, who was informed about the session procedure and was provided with the Ud-TIC questionnaire beforehand so that they would be familiar with it. Completion of the questionnaire took between 12 and 20 minutes.

2.3. Data Analysis

A descriptive analysis of the sample was conducted by calculating measures of central tendency (mean and standard deviation). The Kolmogorov–Smirnov (K–S) normality test was applied, revealing that the sample did not follow a normal or symmetrical distribution ($p \leq .05$). Consequently, non-parametric tests were used, specifically the Mann–Whitney U test (for two groups) and the Kruskal–Wallis test (for more than two groups). To establish relationships between variables, contingency tables and Pearson's chi-square test were employed to determine the existence of statistically significant associations. Cramer's V was used to assess the magnitude of statistically significant associations.

2.4. Ethical Considerations

This research was approved by the Research Ethics Committee of the University of Murcia. The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Research Ethics Committee of the University of Murcia, Protocol code 2306/2019. Students participated voluntarily and anonymously when completing the questionnaire. The study complied with the privacy and data protection policy (APA Standard 4.1). Likewise, participants were informed that they could withdraw from the study at any time (APA Standard 8.2).

3. Results

First, the results addressing the first objective are presented. This objective focused on describing psychological behavioural indicators of problematic video game use at the general level and according to sex and school year.

3.1. Psychological Indicators of Problematic Video Game Use at the General

Level, by Sex and School Year

The data analysis, as shown in Table 1, indicates that 24.4% of adolescents abandon what they are doing in order to play video games. 19.8% of the young participants who report high console use become angry or irritated when someone bothers them while they are playing, while this occurs "sometimes" for 26.6% of them. Furthermore, 11.9% of the students feel the need to spend increasingly more time playing in order to feel satisfied.

Table 1. Descriptive statistics of the indicators of problematic video game use.

Ítem	Always n (%)	Almost always n (%)	Quite often n (%)	Sometimes n (%)	Never n (%)	M	Md	SD
You stop what you are doing in order to play video games	91 (8.3)	105 (9.5)	73 (6.6)	278 (25.2)	554 (50.3)	4.00	5	1.30
You get angry or irritated when someone bothers you while you are playing	60 (5.4)	62 (5.6)	97 (8.8)	293 (26.6)	589 (53.5)	4.17	5	1.15
You feel the need to spend increasingly more time playing in order to feel satisfied	31 (2.8)	40 (3.6)	61 (5.5)	179 (16.3)	790 (71.8)	4.50	5	0.96

Note. Values indicate frequency (n) and percentage (%). M = mean; Md = median; SD = standard deviation.

With regard to sex, the results indicate the existence of statistically significant differences between boys and girls regarding disproportionate reactions to interruptions during online gaming, with boys showing the greatest level of problematic behaviour ($p < .001$). Thus, 30% of boys become angry or irritated if someone bothers or interrupts them while they are playing. Among girls, by contrast, only 10% become upset if their gaming activity is interrupted. Additionally, 17% of boys report that they frequently feel the need to spend increasingly more time playing video games in order to feel satisfied, followed by 24% who state that this occurs sometimes ($p < .001$). Likewise, 28% of boys report that they frequently neglect their tasks in order to play video games, whereas among girls only 20% neglect or abandon other activities in order to play. Statistically significant differences were found between neglecting tasks to play video games and sex ($p < .001$).

Regarding school year, no statistically significant differences were found in relation to the occurrence of irritation or anger when gameplay is interrupted ($p = .308$), nor with respect to the need to spend increasingly more time using the console in order to feel satisfied ($p = .150$). However, the data analysis revealed statistically significant differences according to school year with respect to neglecting tasks in order to play video games, with third-year secondary education students (3rd ESO) showing the greatest level of problematic behaviour ($p < .001$). Thus, 35% of students in 3rd year of compulsory secondary education frequently abandon what they are doing in order to play video games, compared with 25% of students in 1st year, 22% of students in 4th year, and 18% of students in 2nd year.

3.2. Relationship Between Gaming Frequency and Indicators of Problematic Video Game Use

To address the second objective, which focused on analysing the relationship between video game use frequency and indicators of problematic video game use, it should first be noted that the participants who showed the highest levels of anger when interrupted or bothered while playing were those who played every day (27.5%), followed by those who played several times a week (6.3%), only at weekends (6.3%), rarely (3.6%), and never (2.0%). Statistically significant differences were found between video game use frequency and irritability or anger when gameplay is interrupted ($\chi^2(16) = 249.090$, $p \leq .001$) with a small effect size ($V < .10$). Therefore, the data analysis indicates that a higher frequency of video game use is associated with greater irritability when gameplay is interrupted.

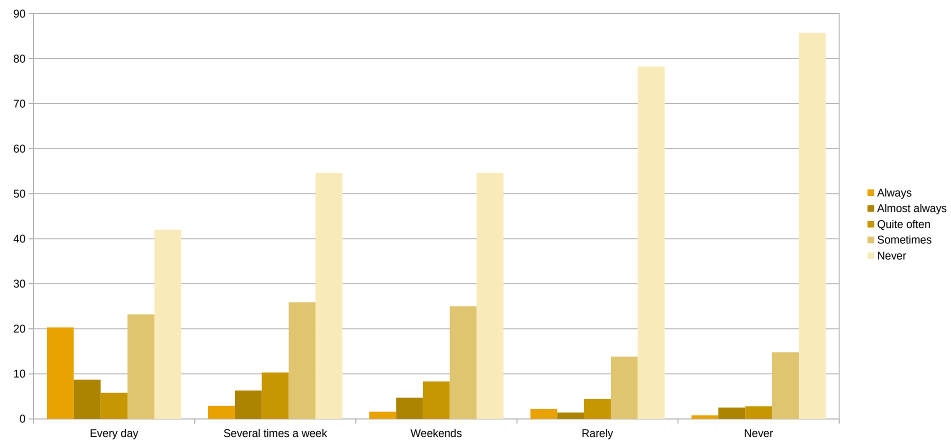

Figure 1. Relationship between the frequency of video game use and the need to spend more time playing.

Note. The values represent the percentage of adolescents in each category of gaming frequency (daily, several times a week, weekends, rarely, and never) who report an increasing need to spend more time playing.

Along these lines, as shown in Figure 1, 29% of adolescents who play daily report needing to spend increasingly more time playing in order to feel satisfied. In contrast, the percentage reporting this need is noticeably lower among those who play several times a week (9.2%), only at weekends (6.3%), rarely (3.7%), and never (3.4%). A statistically significant relationship was found between video game use frequency and the need to spend increasingly more time playing in order to feel satisfied ($\chi^2(16) = 180.614$, $p \leq .01$) with a small effect size ($V < .10$).

Additionally, those young people who report a higher frequency of video game use are also the ones who most frequently neglect their responsibilities in order to continue playing. Thus, 34.8% of those who play every day neglect their responsibilities in order to spend more time playing, followed by 23.6% of those who play several times a week, 11.4%of those who play only at weekends, and 17.5% of occasional players. A statistically significant relationship was found between video game use frequency and neglecting responsibilities of various kinds ($\chi^2(20) = 130.563$, $p \leq .01$) with a small effect size ($V < .10$).

3.3. Association Between Problematic Video Game Use and Technostress

To address the third objective, which focused on analysing the relationship between indicators of problematic video game use and technological stress, it should be noted that a statistically significant association was found between irritability when gameplay is interrupted and technological stress ($\chi^2(4) = 30.550$, $p \leq .001$) with a small effect size ($V < .10$). Thus, 48.3% of the young people who always become irritated when their gameplay is interrupted and 50.0%of those who become irritated almost always report feeling technologically stressed, whereas among those who become irritated only sometimes when prevented from playing, only 24.9% report feeling stressed. Likewise, as shown in Figure 2, a statistically significant relationship was found between the need to spend increasingly more time playing in order to feel satisfied and technological stress ($\chi^2(4) = 47.068$, $p \leq .001$) with a small effect size ($V < .10$). This indicates that those users who report a greater need to spend more time playing (64.5% responding Always and 60% responding Almost always) experience higher levels of technological stress than those who report this need only Sometimes (34.1%).

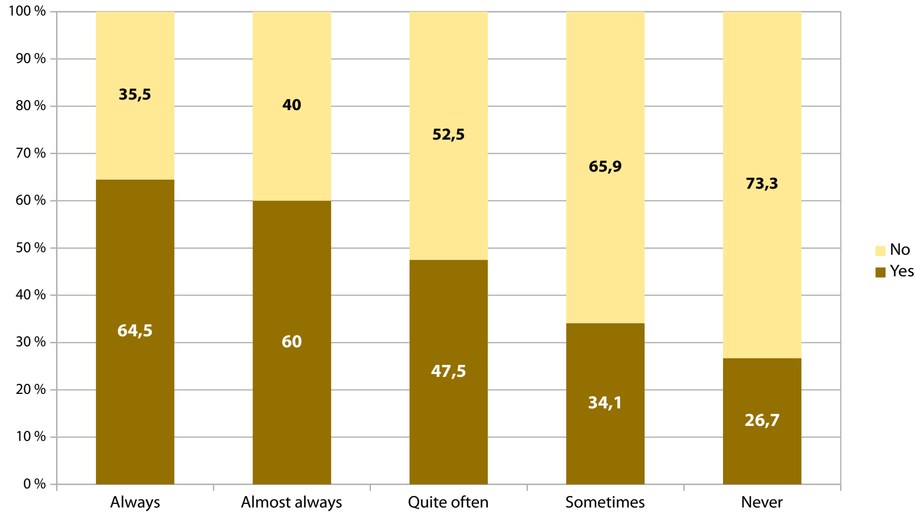

Figure 2. Relationship between technological stress and the need to spend increasingly more time playing.

Note. Values represent the percentage of adolescents reporting technological stress according to their need to spend increasingly more time playing (Never, Sometimes, Quite often, Almost always, and Always)

Additionally, the data analysis highlights that those young people who stop going out with their friends in order to play video games are also the group reporting the highest levels of technological stress ($\chi^2(4) = 14.901$, $p \leq .005$) with a small effect size ($V < .10$). Thus, 63% of students who always stop going out in order to spend more time playing video games report feeling stressed, followed by 50% of those who almost always stop going out to spend more time playing. In contrast, among students who stop going out with their friends in favour of gaming only sometimes, the percentage of stressed adolescents decreases considerably (37.2%). Conversely, no statistically significant relationship was found between neglecting responsibilities in order to play video games and technological stress ($\chi^2(4) = 7.766$, $p \leq .101$) with a small effect size ($V < .10$).

3.4. Frequency of video game use and its impact on social skills

Finally, in order to address the last specific objective, which focused on analysing the frequency of video game use and its impact on social skills, it is necessary to point out that students who make more intensive use of the video game console show lower assertiveness when expressing a different opinion face-to-face than those who play less frequently. Thus, 31.8% of young people who play video games every day admit that expressing an opinion different from that of another person during face-to-face interaction is slightly (10.1%) or very slightly (21.7%) characteristic of themselves. In contrast, among those who play only at weekends, only 18.8% acknowledge that expressing a different opinion in a face-to-face interaction is slightly or very slightly characteristic of themselves. Among occasional players, this percentage is 17.7%. The data analysis indicates the existence of a statistically significant relationship between the frequency of video game console use and the ability to express a different opinion in person ($\chi^2(20) = 46.640$, $p \leq .05$) with a small effect size ($V < .10$).

With regard to the virtual environment, those adolescents who use the console more frequently are also those who show lower levels of assertiveness ($\chi^2(16) = 27.361$, $p \leq .05$, $V = .038$). In this regard, 31.9% of users who use the console every day indicate that expressing a different opinion on the Internet is slightly or very slightly characteristic of their way of being. In contrast, among weekend players, this percentage decreases to 22.9%. Likewise, the data analysis highlights the existence of a statistically significant relationship between the frequency of video game console use and the preference for virtual communication ($\chi^2(16) = 72.996$, $p \leq .01$) with a small effect size ($V < .10$), with those students who report the highest frequency of use being those who prefer virtual communication.

Thus, as shown in Table 2, 46.3% of students who play the console every day state that they find it easier to interact through the Internet. By contrast, only 14.2% of those who rarely play video games and 14.3% of those who never use the console prefer this type of virtual interaction.

Table 2. Relationship between the frequency of video game use and preference for virtual communication.

Frequency of video game use	Always n (%)	Almost always n (%)	Quite often n (%)	Sometimes n (%)	Never n (%)	M	Md	SD
Never	24 (6.1)	32 (8.2)	46 (11.8)	134 (34.3)	155 (39.6)	3.90	4	1.18
Rarely	16 (5.8)	23 (8.4)	38 (13.8)	101 (36.7)	97 (35.3)	3.87	4	1.15
Weekends only	9 (4.7)	22 (11.5)	26 (13.5)	60 (31.3)	75 (39.1)	3.89	4	1.18
Several times a week	19 (10.9)	25 (14.4)	22 (12.6)	55 (31.6)	53 (30.5)	3.56	4	1.35
Every day	21 (30.4)	11 (15.9)	9 (13.0)	16 (23.2)	12 (17.4)	2.81	3	1.52
Total	89 (8.1)	113 (10.3)	141 (12.8)	366 (33.2)	392 (35.6)	—	—	—

Note. Values indicate frequency (n) and percentage (%). M = mean; Md = median; SD = standard deviation. The response variable corresponds to the perceived ease of interacting through the Internet rather than through face-to-face interaction.

Likewise, 23.1% of adolescents who use the video game console every day stop going out with their friends in order to spend more time playing. The same occurs among 8.4% of those who play several times a week, 2.1% of those who play only at weekends, and 1.1% of those who rarely play.

These results indicate the existence of a statistically significant relationship between the frequency of video game useand giving up social outings with friends in order to spend more time playing, with those students who report the highest frequency of use also being those who most neglect their social circle in favour of online gaming ($\chi^2(16) = 108.722$, $p \leq .01$) with a small effect size ($V < .10$).

4. Discussion and Conclusions

The problematic use of online video games is a phenomenon that has gained increasing relevance in recent years, in parallel with the global rise of ICT. Recent literature has highlighted its association with indicators of psychological distress, such as anxiety, depression, insomnia, and stress, as well as with difficulties in interpersonal relationships (Cudo et al., 2019; Kuss & Griffiths, 2012). For these reasons, understanding the mechanisms involved in problematic video game use is of key importance.

The present study sheds light on the understanding of problematic video game use among adolescents, indicating that one in every five young people reports abandoning, interrupting, or neglecting their school obligations in order to spend more time playing video games. These results differ from those reported by García-Oliva et al. (2017), who found that only one in every ten students who plays video games experiences interference in daily life. These findings point to a gradual increase in the interference of ICT in general, and of video game consoles in particular, in adolescents' lives over recent years.

On the other hand, sex appears to be a determining factor. In this regard, the present study found that boys become angrier than girls when they are interrupted while playing, and they are also more likely to interrupt other activities in order to continue using video games. These findings are consistent with those reported by Díaz-López et al. (2020), who also found greater video game consumption among boys than among girls.

With regard to technological stress, the results of the present study show that those adolescents who report indicators of problematic video game console use (such as becoming angry when interrupted, the need to spend increasingly more time playing, or giving up social activities) present higher levels of technological stress. These findings are consistent with previous research identifying an association between problematic video game use and perceived stress (Canale et al., 2019; Pallavicini et al., 2022; Romero et al., 2025).

One possible interpretation of this relationship may be linked to certain characteristics of video games, such as the intensity of stimulation or emotional involvement, especially in competitive or multiplayer settings (Ellithorpe et al., 2022). However, given the cross-sectional nature of the study, these results should be interpreted in terms of association rather than causality. Furthermore, extensive use may be associated with more severe psychological disorders such as anxiety and depression (Canale et al., 2019).

Likewise, it has been confirmed that a high frequency of video game use is associated with the need to spend increasingly more time playing in order to feel satisfied. This may be related to the fact that individuals can experience a greater sense of belonging to the group within the video game or during gameplay, especially in multiplayer game), which would imply greater perceived social support, as also occurs with the use of social networking sites (Caba-Machado et al., 2022).

In this regard, the findings highlight the individual psychological distress associated with problematic video game use during adolescence and the need to address this issue through primary and secondary prevention strategies, such as parental training or empowerment programmes.

With regard to social skills, the results indicate that a higher frequency of video game use is associated with lower levels of assertiveness, both in online and offline contexts. These findings are consistent with previous studies that have identified relationships between intensive video game use and certain difficulties in social interaction (Sauter et al., 2021; Vallejos & Capa, 2010; Valdéz-Castro et al., 2025). Likewise, it is observed that a relevant proportion of adolescents reduce the time devoted to face-to-face social activities in favour of online gaming, which may be linked to changes in forms of socialisation characteristic of digital environments.

Additionally, it was found that two out of every ten adolescents stop going out with their friends in order to spend more time playing. These results are considerably higher than those reported by García et al. (2014). Likewise, those students who report the highest frequency of video game console use are also those who most neglect their social circle in favour of online gaming. The importance of these findings lies in a broader problem affecting a large proportion of today's society: loneliness, which, as reported in the literature, is associated with problematic video game use (Cudo et al., 2019).

Therefore, it is concluded by highlighting that one out of every five young people acknowledges abandoning, interrupting, or neglecting their school responsibilities in order to spend more time playing video games. The results obtained indicate that problematic video game use is associated with higher levels of technological stress in adolescents, as well as with indicators of interference in academic and social life. Likewise, intensive ICT use is associated with possible difficulties in the development of social skills, revealing a partial shift from face-to-face interactions towards virtual environments. Thus, two out of every ten adolescents have stopped going out with their friends in order to continue playing video games.

In light of these findings, the need to design and implement parental education and training programmes to promote a more adaptive use of video games in particular, and ICT in general, among adolescents becomes evident. This study is not without limitations. In this regard, the data were obtained through adolescents' self-reports; therefore, future research should gather information from other sources, such as families and teachers, which would make it possible to triangulate the information and gain a deeper understanding of the causes of this problem.

As a future line of research, the design and implementation of a parental training programme on the adaptive use of video games during adolescence is proposed, together with the promotion of parental empowerment training programmes and actions.

With this study, which forms part of and is framed within the broader research conducted by Díaz-López (2021), the aim is to deepen our understanding of this issue and to move closer to understanding the consequences of problematic technology use among Generation Z young people, who, immersed in a fully digitalised society, require the use of technology in every aspect of their lives.

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REVIEW / RESEÑA / RESENHA

Ballesta Pagán, J. (2025). *Una mirada a la educación*. Graó.

Joaquín Paredes-Labra *

Reading Javier Ballesta in this work brings to mind others from a Spanish tradition of teachers collaborating with the media. They did so on topics related to educational reality and life in the community, denouncing problems or proposing changes, with sensible proposals for a fairer society. In these works there was a desire to engage in «public pedagogy.» They also belonged to a period in which Spain was transitioning to democracy. At that time, the construction of coexistence was important. That task is perhaps one of the most cherished by teachers in the development of their work. And it was something the country needed. José Manuel Esteve, Miguel Ángel Santos, and Jesús Asensi— all linked, incidentally, to the south—set themselves to this task in their works. Let us now welcome the renewal of that desire to bring good sense and coexistence.

In this reflection on the everyday life of the school and its relationship with the community, there are a great many themes, as Javier Ballesta shows in his collaboration with a column in a widely circulated regional newspaper, which is the source of this work. Despite its immediacy, it offers an urgent and timeless review of educational reality.

The book is structured in five parts: «Realities and Challenges,» «The Educational Debate,» «Teachers Are Indispensable,» «The Pandemic That Changed Our Lives,» and «At Street Level.»

«Realities and Challenges» analyses problems of great educational and social importance, such as the deterioration of reading comprehension, gender-based violence, grade repetition, online harassment, the analysis of PISA test data, and external assessment exams.

«The Educational Debate» humorously assesses recent non-university education laws.

«Teachers Are Indispensable» denounces the limited social recognition of their work, while at the same time acknowledging their perseverance and responsibility in educational outcomes.

«The Pandemic That Changed Our Lives» analyses educational reality during that terrible period and what it meant for students and teachers.

«University Discontent» analyses the widespread demotivation within the university community, the mismatch between educational provision and labour-market demand, the increasing precariousness of teaching staff, the lack of digital connectivity, the flight of talent abroad, and the changing of university laws with each legislative term.

The sixth and final part examines, «At Street Level,» realities such as poverty and youth unemployment, issues that are all constitutive of the strenuous efforts made by schools.

Although it may appear to be a work of interest only to education professionals, its themes have the pulse of social debates that go far beyond that sphere. They speak of the consequences of educational organisation in the lives of millions of children and young people, of its professionals—a very broad collective—and of their families. For example, learning to read, surviving the education system and its meritocratic traps, building a kind and dialogic society rather than one that hides behind anonymity, and providing tools to preserve dignity as women and as people are all tasks involved in becoming full citizens. And the work is committed to the social implications of the everyday action of schools in the pursuit of better citizenship and a better society.

In all of this, it offers a critical and close perspective on educational problems of enormous significance. Not surprisingly, the author is seasoned in all levels of education and has carried out relevant research. Seeking to capture the public's attention, we find ourselves before a fast-paced, vibrant, and political work.

Now, as during Spain's democratic transition, this work is timely, at a moment when particularly unjust situations are recurring in the world, where tolerance and understanding of others' points of view can seem like a distant horizon. In the face of the painful fractures caused by sometimes absurd political statements, Ballesta feels the need to push us toward the moral obligation not to remain silent, to hold up a mirror to the shames into which citizens are being dragged, to denounce social oppression, to give importance to empathy, and to value those who work for others; in short, to make present what public education has always aspired to be, and to give it an important place at the heart of our society.

DESCARGA

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RESEÑA / RESENHA / REVIEW

Area-Moreira, M. (2025). *Luces y sombras de la IA en la educación superior. Didáctica para el pensamiento crítico.* RIULL

Dulce María Verónica Montes de Oca Olivo *

When beginning research on the uses of Artificial Intelligence among students and on strategies for validating information, I came across this book, which stands as a lucid, timely, and profoundly necessary academic intervention, showing readers the advantages and disadvantages of using AI in teaching. It is a work that appeals to the professional conscience of university teaching staff and to the intellectual commitment of students. From the very first pages, the author seeks to fill a gap created by the absence of didactic educational models to guide the pedagogical integration of AI into university teaching. The book consists of three chapters that demonstrate that AI can be an ally, even in a context saturated with publications focused on applications, platforms, and technological promises.

This book stems from the author's original idea. He gave a presentation at the Conference on Artificial Intelligence in Teaching, organised by the University of La Laguna, mainly with the support of AI—ChatGPT version 4.0—as well as Gemini and Copilot. He asked these tools to produce a descriptive narrative of the ideas expressed in that presentation, as well as the images illustrating different aspects of the text. Thus began a constant dialogue with the machine. What is particularly significant is that the author himself explicitly states his use of generative tools in the writing of the book. This methodological transparency turns the work into an example of how such interaction between human beings and AI can take place. This gesture not only adds coherence to the discourse, but also invites the academic community to experiment critically with the tools it analyses, thereby fostering critical thinking.

The author offers a historical overview ranging from the nineteenth-century myth of the «teaching machine» to today's generative systems. He evokes Jean-Marc Côté's futuristic visions and B. F. Skinner's proposals, as well as the confrontation between programmed instruction and the constructivist theses associated with Seymour Papert's approach. Finally, he arrives at the central axis of this work: the era of AI, with a focus on the automation of learning in Higher Education.

The first chapter begins with the transition from printed books to the arrival of artificial intelligence. Área Moreira has shown that the expansion of the internet and cyberspace has not only diversified sources of information, but has also brought about a one-directional shift away from the traditional classroom. AI appears as a dominant element that calls for a reformulation of teaching roles. The thesis is that it is not a matter of adding yet another tool to the methodological repertoire, but of embracing a pedagogical disruption.

The second chapter is devoted to overcoming the dichotomy between technophilia and technophobia. In particular, it raises awareness of the lights and shadows of AI. Its use can improve teaching, although risks also exist. On the one hand, the uncritical acceptance of AI may lead to a depersonalised education that reinforces prejudices; on the other, a humanistic and equitable education emphasises the need to make ethical and critical use of AI. The «lights» of AI constitute an analytical inventory of its potential for teachers and students alike: the automation of repetitive tasks, support in course design, predictive analytics, adaptive assessment, and personalised tutoring. The author examines each area rigorously. Particularly noteworthy is his insistence that AI does not replace the teacher, but rather can free up time for other tasks involved in teaching: guiding, accompanying, and problematising.

Moreover, students can benefit from simplified access to information, support in academic writing, and the promotion of deep and meaningful learning centred on reflection, understanding, and self-regulation. The «shadows» occupy a central place in the analysis because the book encourages the conscious and responsible use of AI, placing academic ethics first in order to avoid conflicts related to plagiarism, the copying of academic work, and exposure to hallucinations or false data generated by this tool, as well as the perpetuation of ideological biases. This leaves us with a reflection: What kinds of tasks are we proposing that can be solved mechanically by a generative system?

The book's major contribution lies in its third part, where a didactic model for critical learning with AI is outlined. Here the work acquires a highly valuable propositional dimension. Área-Moreira leads us to another reflection: How can we educate cultured, competent, and critical subjects in a society traversed by algorithms? One of the merits of this book is that it raises the need for a strategic proposal requiring training in competences related to questioning, comparison, critical dialogue with the generated results, verification, personal reworking, and ethical reflection on authorship. These constitute central axes, leading students to engage in constant reflective dialogue with AI and to produce work in which they express their own knowledge, using AI tools while making the traceability of thought visible. Once again, the author places us on the epistemological and ethical plane, and does so in a way that is understandable and plausible both for teachers and for students, enabling them to move through a cyberculture and become reflective, critical subjects in this era of AI, thus paving the way for a paradigm shift in twenty-first-century education.

In conclusion, in these times of digital transformation in education, this work reminds us that educational innovation is not synonymous with technological novelty, but rather with a conscious transformation of formative practices. Reading it is already an indispensable exercise in critical thinking for all those who wish to understand, shape, and improve the future of higher education in the era of AI.

FOR AUTHORS

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ARTICLES

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