





Generative artificial intelligence in teacher education: perceptions, attitudes, and transformative digital resources

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ABSTRACT

Generative Artificial Intelligence (GAI) is reshaping higher education, showing early evidence of potential to optimize teaching and learning processes through personalized support, content creation, and assessment automation. However, its integration into teacher training presents challenges in terms of perception, attitudes, and intention to use. This study analyzes the impact of implementing GAI tools in the training of preservice teachers, assessing their influence on the perception of their educational value and their willingness to adopt them. A mixed-method approach was used with 180 participants from the Master's in Teacher Training in Spain, who took part in virtual workshops where they explored GAI tools such as ChatGPT, QuizCube, Beautiful.ai, Convai, Neiro, and Synthesia for the design of educational materials. Through pre and postintervention questionnaires, a positive impact on the perception of AI was observed, increasing acceptance and confidence in its pedagogical use. The results show a significant improvement in participants' intention to integrate AI into teaching and a positive evaluation of its educational usefulness. Incorporating GAI as an innovative methodology in teacher training seems to increase their confidence and security in its use, recommending the development of training strategies that enhance its critical and effective adoption in the educational field.

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Introduction

In the context of higher education, students' perceptions, and more specifically of Artificial Intelligence (AI) have emerged as an area of growing interest in educational research and Social Sciences, due to the AI ability to optimize teaching and learning processes (Grájeda et al., 2024; Rahiman & Kodikal, 2024). The integration of AI, and more specifically Generative Artificial Intelligence (GAI), into teacher training has been recognized as a promising development that may support personalized instruction, streamline administrative processes, and promote innovative methodologies grounded in data-driven decision-making (Al-Zahrani & Alasmari, 2024). However, its potential benefits coexist with concerns about pedagogical dependency, ethical use, and data protection, which are increasingly central to educational research (Nguyen, 2025). The implementation of AI in education continues to raise significant questions regarding its pedagogical, ethical, and affective implications, particularly how it shapes the perceptions, attitudes, and willingness of preservice teachers to integrate such technologies into their practice. The acceptance and adoption of AI in teaching

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depend on various factors, such as teacher preparation, confidence in its usefulness, and proper training for its implementation (Parveen & Alkudsi, 2024). Therefore, the acceptance and adoption of AI in teacher training remain a key challenge that requires appropriate training strategies to ensure its effective implementation and utilization in educational contexts.

Recent studies have shown that AI-based educational interventions can transform the perception of the educational value of this technology and increase its acceptance in the training context (Alpizar Garrido & Martínez Ruiz, 2024; Bahroun et al., 2023). In particular, exposure to generative AI tools, such as virtual assistants and automated assessment platforms, has been identified as a key factor in increasing the confidence of preservice teachers and facilitating its integration into teaching (Chan & Hu, 2023; Guan et al., 2025). Furthermore, its implementation drives the adoption of adaptive and personalized methodologies in the educational process, which contributes to improving teaching and learning (Iqbal et al., 2024; Singh et al., 2025). While these contributions underscore the pedagogical advantages of AI, they must be balanced with critical perspectives that highlight the social, ethical, and emotional dimensions of technology use in education.

The integration of AI in higher education has undoubtedly expanded pedagogical possibilities, yet recent literature stresses the importance of moving beyond a purely optimistic discourse. Concerns related to equity, privacy, and ethical responsibility have become central in contemporary debates (Daher, 2025; Dimitriadou & Lanitis, 2023). The promise of democratizing access to knowledge may inadvertently deepen digital divides between technologically privileged students and those in under-resourced contexts if equitable access and digital literacy are not ensured (Daher, 2025). Moreover, the widespread use of AI platforms involves large-scale data collection from students and educators, raising questions about consent, transparency, and the potential misuse of personal information (Adel et al., 2024; Nguyen, 2025). Scholars such as Caboni & Pizzichini (2025) further caution that over-reliance on automated tools may compromise intellectual autonomy and critical reasoning. In addition, authors like Bianchi (2024) and Dominguez Vera et al. (2024) highlight that AI must remain a complement rather than a substitute for the human dimension of teaching, as creativity, empathy, and critical dialogue are irreplaceable elements of the learning process. Finally, a responsible and sustainable use of AI requires strong ethical frameworks that prioritize equity, academic integrity, and reflective professional judgment (Vera et al., 2024).

Despite these benefits, the integration of AI in higher education faces challenges such as the lack of specific training, the perception of technological complexity, and ethical concerns about the automation of learning (Airaj, 2024; Doğan et al., 2025). To address these challenges, several authors emphasize the need to develop training programs that not only provide solid technical knowledge about AI but also promote critical and reflective thinking in its application (Nguyen et al., 2023; Walter, 2024). In this way, preservice teachers will be able to evaluate its effectiveness in different educational settings and determine how these technologies can complement and enrich their pedagogical practice (Yadav, 2025).

In this context, the integration of AI into teacher training programs has the potential to positively alter preservice teachers' perceptions of this technology and increase their willingness to adopt it in their educational practice (Mulyani et al., 2025; Wang & Huang, 2025). This helps reduce resistance and fear of replacement by understanding that AI can be a complementary tool in the teaching and learning process (Chan & Tsi, 2023). Furthermore, early and guided exposure to AI facilitates the development of advanced digital skills, allowing preservice teachers to integrate AI tools critically, ethically, and effectively into their pedagogical methodologies. This not only improves their technological skills but also prepares them to teach their own students how to use AI responsibly and reflectively (Melisa et al., 2025). Additionally, the inclusion of AI in teacher training promotes the creation of innovative pedagogical strategies, fostering a more dynamic and adaptive learning experience. In this way, future educators can view AI as a complementary resource that enhances teaching and improves learning processes in various educational contexts (Wang et al., 2023).

Despite the potential of AI to personalize teaching and optimize educational processes, its adoption in the teaching field is not without challenges. Among the main concerns of educators is the quality of learning, as there is a risk that students may use AI without adequate reflective processes, which could affect their cognitive and critical development (Sardi et al., 2025). Additionally, some teachers perceive that AI could alter their professional role or reduce their presence in the classroom, creating uncertainty about their role in an increasingly automated teaching environment (Garcia, 2025). These concerns are

often linked to a lack of knowledge and specific training in the pedagogical use of AI, which limits their willingness to effectively integrate it into their educational practice (Alwaqdani, 2025).

In light of this situation, initial teacher training represents a key opportunity to assess how exposure to AI can alter preservice teachers' perceptions and their intention to use these technologies in the classroom. Several studies have indicated that immersion in learning environments that incorporate AI can strengthen positive attitudes toward its use and encourage greater use of these tools in teaching (Ateş & Gündüzalp, 2025; Chanda et al., 2025; Ren & Wu, 2025).

The central purpose of the study is to measure how exposure to AI tools influences preservice teachers' perceptions and their willingness to use these technologies. Through a specific training intervention, changes in their attitudes and their willingness to adopt AI in the classroom will be evaluated. The relevance of this research lies in its ability to provide empirical evidence on the relationship between AI training and preservice teachers' willingness to integrate these tools into their professional practice, contributing to the design of more effective training strategies in higher education. Therefore, AI is presented as a key tool for the modernization of traditional pedagogical practices, offering opportunities to personalize learning and adapt it to the individual needs of students (Dei, 2025; Mamazova Zarifa, 2025). Nevertheless, to maximize its benefits, a comprehensive and ethically grounded approach is essential, one that integrates technological competence with social awareness, data ethics, and the reflective capacity necessary to ensure an inclusive and human-centered use of AI in education (Vera et al., 2024).

Objectives and hypotheses

General objective

To analyze the impact of Generative Artificial Intelligence on university education, evaluating its influence on the perception, attitude, and intention of use by preservice teachers, in order to understand its potential to transform the teaching and learning process.

Specific objectives

To explore the perceptions and attitudes of future teachers towards Generative Artificial Intelligence in the classroom, focusing on its perceived usefulness, relevance, and ethical implications in the learning process.

To identify the key pedagogical functions and characteristics of Generative AI-based digital resources that future teachers consider most valuable for teaching and learning, beyond specific tools or platforms.

To analyze how exposure to GAI-based educational resources influences the intention of preservice teachers to integrate this technology into their professional practice.

Therefore, this study poses the following research questions:

RQ1 (Cognitive): How does exposure to Generative AI in university education influence preservice teachers' perceptions of its educational value and their understanding of its appropriate pedagogical integration

RQ2 (Affective): What attitudes and emotional responses do preservice teachers express regarding the use of Generative AI as an educational resource in classroom settings?

RQ3 (Behavioral): How does exposure to AI-based digital resources influence the intention of future teachers to adopt and use this technology in their educational practice?

Thus, the study proposes the following research hypotheses:

H1 (Cognitive): The integration of Artificial Intelligence in university education is perceived as a valuable strategy to improve teaching and learning processes, increasing its acceptance and recognition in the academic field.

H2 (Affective): preservice teachers have favorable attitudes and a high level of interest towards Generative Artificial Intelligence in teaching, highlighting its potential to enhance the educational experience.

H3 (Behavioral): The availability and use of AI-based digital resources foster the intention of preservice teachers to incorporate this technology into their educational practice, promoting an innovative and digitized approach.

Methodology

Participants and context

The sample was selected through a non-probabilistic intentional sampling, aimed at students enrolled in the mandatory course 'Educational Processes and Contexts' (6 ECTS) in the first semester of the Master's in Teacher Training for Compulsory Secondary Education, during the 2024–2025 academic year at Atlántico Medio University (UNAM). Two groups were formed. The first Validation Sample (PRE), with $n = 242$ participants, were recruited for the initial validation of the learning questionnaire. The second Intervention Sample (PRE-POST), with $n = 180$ participants, completed both the PRE and POST questionnaires. The demographic characteristics (age, gender, academic level) of both samples are detailed in [Table 1](#).

The research was conducted in a virtual context over four synchronous practical sessions, each lasting two hours, as part of a structured e-learning program delivered through a virtual platform. Before starting the intervention, all participants were informed about the study and asked for written informed consent, ensuring the anonymity of their responses and the option to withdraw at any time, in accordance with the Declaration of Helsinki (Sprumont et al., 2007). Additionally, the research design and the questionnaire were approved by the Ethics Committee of Atlántico Medio University (code CEI/01-017). The sample size for the intervention was justified through an a priori analysis using G*Power for a paired samples t-test (difference between paired means). With an expected effect size ($d_z = 0.5$), a significance level of 0.01, and a power of 0.95, the analysis indicated that 66 participants were required (Faul et al., 2009). The sample of 180 participants far exceeds this minimum, ensuring the statistical robustness necessary to detect significant differences between the PRE and POST evaluations.

Research design

This paper aims to examine the effect of Artificial Intelligence on teacher training, considering its impact on the perception, attitude, and intention of use by preservice teachers, with the purpose of identifying its potential to innovate and improve the teaching and learning process. The study adopted a quantitative and descriptive approach with a cross-sectional design, focusing on analyzing students' attitudes towards artificial intelligence, as defined by Rodríguez-García et al. (2021).

Similarly, this study adopts a mixed-methods approach, which can be understood as a process of collecting, analyzing, and integrating both quantitative and qualitative data within the same research (Azorín et al., 2024). This methodology not only allows for a rigorous examination of the information obtained but also enables the organization and systematization of the results in a structured manner. Additionally, the types of studies used were descriptive, aimed at identifying characteristics of the selected populations in order to provide systematic information that can be compared to other sources (Hernández & Mendoza, 2020). For the bibliographic screening, priority was given to the timeliness,

Table 1. Demographic characteristics of the sample.

Variable	Validation sample (PRE, $n = 242$)	Intervention sample (PRE-POST, $n = 180$)
Gender	Man: 50 (20.7%) Woman: 192 (79.3%)	Man: 37 (20.6%) Woman: 143 (79.4%)
Age (years)	Average: 33.0 ± 8.5 Rank: 22–58	Average: 33.37 ± 8.54 Rank: 22–58
Academic level	Degree: 138 (57.0%) Master's degree: 101 (41.7%) PhD: 3 (1.2%)	Degree: 103 (57.2%) Master's degree: 75 (41.7%) PhD: 2 (1.1%)

relevance, and pertinence of the sources, with the aim of constructing a solid reference framework as a basis for a future state of the art.

Questionnaire design

Data collection was carried out using a Google questionnaire, ensuring prior informed consent and communication of the ethical implications. To this end, an ad-hoc instrument was developed, consisting of two distinct parts, where a 6-point Likert scale (ranging from Strongly Disagree to Strongly Agree) was used to collect responses for each item. In the first part of the questionnaire, demographic data was included (gender, age, academic degree indicating the highest level of education completed), as well as a question to determine whether students were familiar with or knew how to use any Artificial Intelligence (AI) resources or applications. In the second part of the questionnaire, the main questions of this study were included. The aim of our research questionnaire is to assess students' attitudes toward Artificial Intelligence (AI) in three main dimensions: (1) cognitive, (2) behavioral, and (3) affective. For its design, a scale was adapted based on the study Development and Validation of a Scale Measuring Student Attitudes Toward Artificial Intelligence (Suh & Ahn, 2022), which originally consists of 24 items distributed across these dimensions.

Two versions of the same questionnaire were administered at different stages of the intervention: one prior to the training sessions (PRE) and another after the completion of the intervention (POST). The PRE questionnaire included demographic data, questions on participants' familiarity with AI tools, and the full attitude scale, serving to establish a baseline of initial perceptions. The POST questionnaire retained exactly the same structure and attitude scale items to ensure statistical comparability between pre- and post-evaluations. Additionally, the POST version incorporated one exploratory additional item (POST23) designed to identify participants' preferences among the generative AI tools used during the sessions (ChatGPT, Beautiful.ai, QuizCube, Convai, Synthesia, and Neiro). The complete list of questionnaire items, presented in both Spanish and English, is provided in the following Table 2.

Process: justification of the resources and means used

The development of educational materials in this study required the use of various Artificial Intelligence-based tools and advanced digital technologies, with the goal of optimizing the creation, design, and distribution of instructional content in educational environments. The selection of resources was based on criteria of efficiency, automation, adaptability, and quality of the materials generated. Below, in Figure 1, the entire process is described, along with the workflow implemented and the functionality of each tool within the process. The resources were designed and created by us, as instructors, using the mentioned Generative AI tools. Students did not participate in the creation of these materials. Instead, they engaged critically with the resources during the sessions, analyzing their pedagogical value and exploring their potential uses in classroom practice. To enhance understanding of the design process, tutorial video capsules were also shown to demonstrate how each resource had been produced.

Figure 1 illustrates a structured workflow in which Generative AI is seamlessly integrated into the teaching-learning process, with each phase aligned to a distinct pedagogical objective. In Phase 1, ChatGPT supports idea generation and script development, enhancing students' planning and critical thinking skills. Phase 2 leverages Beautiful.AI to foster creativity and digital communication through the design of clear, engaging presentations. In Phase 3, QuizCube introduces adaptive, interactive assessments that promote learner motivation, self-regulation, and retention. Phase 4 demonstrates the use of Synthesia and Convai to create avatar-based educational videos, stimulating audiovisual comprehension and learner engagement. Finally, Phase 5 involves the publication of materials on YouTube, optimized with ChatGPT for accessibility and clarity, thereby cultivating digital communication and critical reflection skills. Collectively, the phases outlined in Figure 1 highlight how GAI tools function not as substitutes for teachers but as catalysts for designing reflective, creative, and meaningful learning experiences. Each tool serves a targeted pedagogical purpose, conceptualization, creation, evaluation, communication, and dissemination, framed by the intentional use of AI to enhance teacher agency and student learning.

Table 2. Demographic characteristics of the sample.

Question/item	Original questionnaire (Spanish)	Translated version (English)
DEM1	Sexo	Sex
DEM2	Indica tu edad.	Age.
DEM3	Titulación (Indica el nivel de estudios más alto que hayas completado)	Degree (Indicate the highest level of education you have completed).
EXP1a	Me siento cómodo/a utilizando tecnologías digitales en general, como ordenadores, software, aplicaciones móviles y otros dispositivos electrónicos.	I feel comfortable using digital technologies in general, such as computers, software, mobile apps, and other electronic devices.
EXP1b	Tengo los conocimientos suficientes para utilizar algún recurso o aplicación sobre inteligencia artificial (IA).	I have sufficient knowledge to use an artificial intelligence (AI) resource or application.
EXP1c	Sé utilizar algún recurso o aplicación sobre inteligencia artificial (IA).	I know how to use an artificial intelligence (AI) resource or application.
	Cognitivo	Cognitive
IT2	Creo que es importante aprender y formarse sobre inteligencia artificial (IA).	I believe it is important to learn about and receive training in artificial intelligence (AI).
IT3	Pienso que la inteligencia artificial (IA) puede ser beneficiosa para el desarrollo de la sociedad.	I think artificial intelligence (AI) can be beneficial for societal development.
IT4	Creo que hay que introducir la Inteligencia Artificial (IA) en la universidad porque esto prevalecerá en la sociedad del futuro.	I believe AI should be introduced at the university level because it will prevail in future society.
IT5	Creo que todos los estudiantes deberían aprender sobre inteligencia artificial (IA) en la universidad	I think all students should learn about AI at university.
IT6	Creo que la Inteligencia Artificial (IA) puede ser una herramienta efectiva y útil para el ejercicio docente y el aprendizaje	I believe AI can be an effective and useful tool for teaching and learning.
IT7	Creo que la implementación de la Inteligencia Artificial mejorará la calidad educativa en el futuro.	I think the implementation of AI will improve educational quality in the future.
IT8	Creo que es necesario conocer las aportaciones de la inteligencia Artificial (IA) en la enseñanza.	I believe it is necessary to understand the contributions of AI to education.
IT9	Considero que es importante tener en cuenta y conocer los riesgos y desafíos de carácter ético y práctico que se presentan con la Inteligencia Artificial (IA).	I think it is important to consider and understand the ethical and practical challenges that arise with AI.
IT10	Creo que debería haber más horas de clase dedicadas a la Inteligencia Artificial (IA) en la universidad.	I believe there should be more class hours dedicated to AI at university.
	Conductual	Behavioral
IT11	Me parece divertido e interesante el aprender sobre Inteligencia Artificial (IA).	I find learning about AI fun and interesting.
IT12	Estoy interesado/a en saber usar los Programas de Inteligencia Artificial (IA) en mi vida diaria.	I am interested in knowing how to use AI programs in my daily life.
IT13	Es interesante utilizar la inteligencia artificial (IA) en el aula para lograr el aprendizaje a nivel individual y colectivo.	It is interesting to use AI in the classroom to achieve learning at both individual and collective levels.
IT14	Quiero seguir aprendiendo sobre Inteligencia Artificial (IA) pues permite el acceso a recursos educativos avanzados.	I want to keep learning about AI because it allows access to advanced educational resources.
IT15	Me motiva que se enseñe y se desarrollen programas de Inteligencia Artificial (IA) en las distintas asignaturas en la universidad.	I am motivated by the development and teaching of AI programs in different university courses.
	Afectivo	Affective
IT16	Pienso que la Inteligencia Artificial (IA) aplicada al aula puede ayudar a que el aprendizaje de los contenidos sea más interesante.	I think using AI in the classroom can make content learning more engaging.
IT17	Pienso que el docente puede fomentar la participación en las clases mediante actividades fundamentadas en la Inteligencia Artificial (IA).	I believe teachers can promote participation in class through activities based on AI.
IT18	Creo que la Inteligencia Artificial aplicada al aula puede fomentar la implicación del alumnado en los procesos de enseñanza y aprendizaje.	I think AI used in the classroom can foster student involvement in teaching and learning processes.
IT19	Pienso que la integración de Programas de Inteligencia Artificial en la universidad puede promover la satisfacción del estudiante y crear una actitud positiva ante el aprendizaje.	I think the integration of AI programs at university can enhance student satisfaction and foster a positive attitude toward learning.
IT20	Creo que la introducción de los Programas de Inteligencia Artificial entre el alumnado es una estrategia de aprendizaje innovadora en el aula universitaria.	I believe the introduction of AI programs among students is an innovative learning strategy in the university classroom.
IT21	Recomiendo el uso de herramientas y plataformas educativas de IA para la adquisición de competencias y contenidos en otras asignaturas en Educación Superior	I recommend the use of educational AI tools and platforms to acquire skills and content in other higher education courses.
IT22	Considero que es necesario conocer herramientas y plataformas educativas (IA) para resolver problemas de la vida cotidiana.	I believe it is necessary to understand educational AI tools and platforms to solve everyday problems.
	Solo para post-test	Only for post-test
POST23	De las siguientes Programas de Inteligencia Artificial utilizados en el aula, ¿cuál te ha gustado más y te parece más interesante para aplicar en el aula?	Of the following AI programs used in the classroom, which one did you like the most and find most interesting to apply in the classroom?

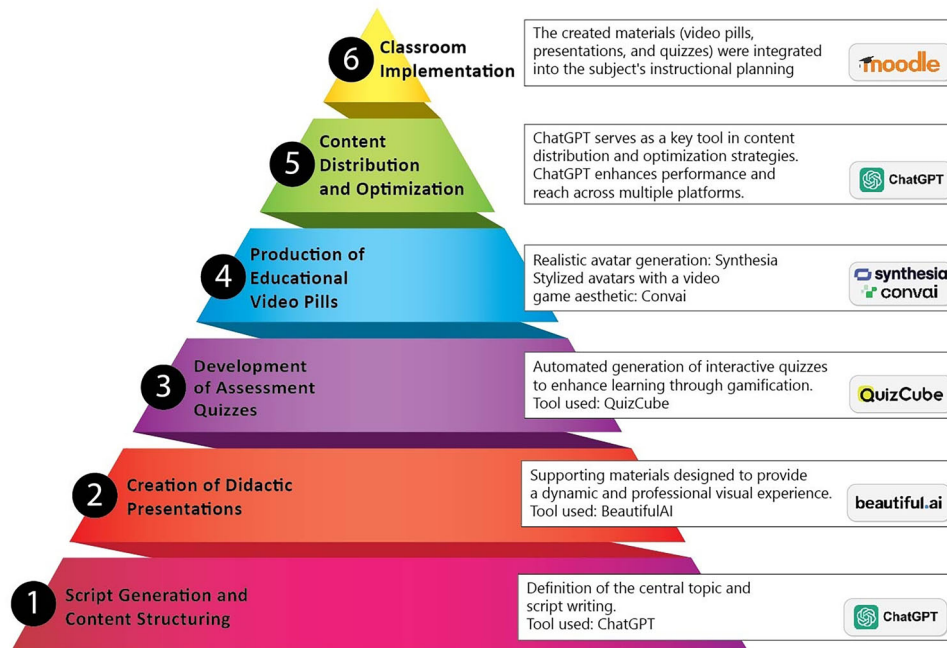


Figure 1. Phases of the process. Main educational objective: Provide a clear understanding of the AI-enhanced learning process by showing how each tool supports planning, creation, evaluation, and communication in a cohesive and purposeful way.

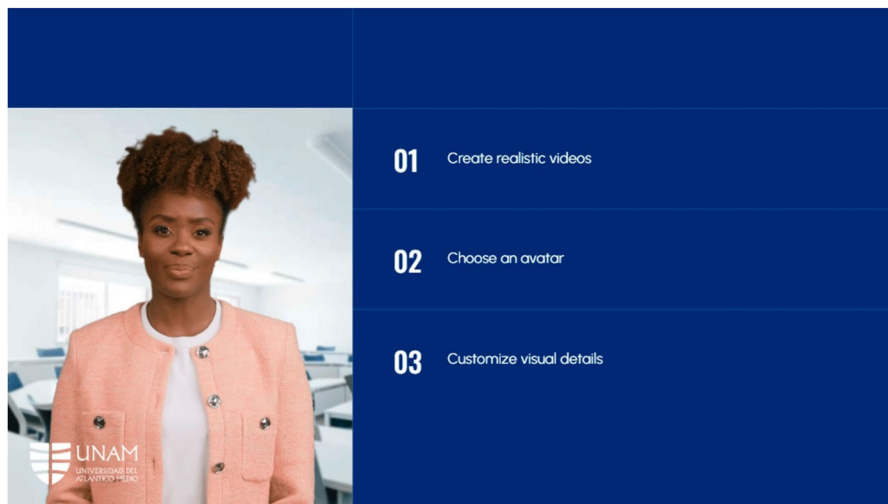


Figure 2. Create educational material with AI in minutes. Main educational objective: Foster organizational, writing, and critical thinking skills through the use of AI in structuring coherent educational materials. (<https://youtu.be/sgY4qde9SDE>).

The first step in creating the educational video capsules consisted of defining the central theme and writing the script. For this, ChatGPT, an AI-based language model, was used, which facilitated the structuring, refinement, and adjustment of the textual content, ensuring its coherence and alignment with the established pedagogical objectives. Additionally, ChatGPT provided recommendations for complementary visual elements, such as images, videos, and slides, to enhance students' understanding of the content (See Figure 2).

For the creation of supporting materials, Beautiful. AI was used, an AI-assisted design platform that facilitates the generation of visual presentations. The script previously created in ChatGPT, along with the visual suggestions, was integrated into this tool, allowing for the optimization of both content and aesthetics of the slides (See Figure 3). Thanks to its automatic adjustment features and design

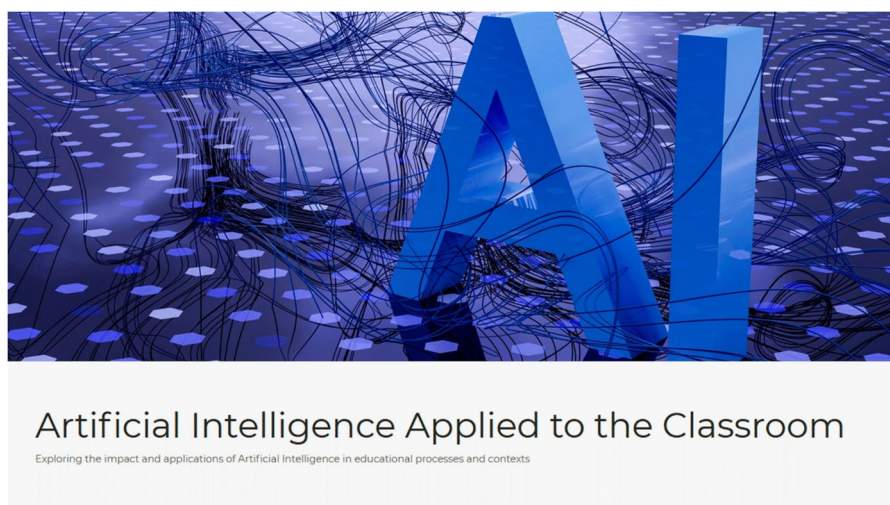


Figure 3. Presentation with Beautiful.AI: Artificial intelligence applied to the classroom. Main educational objective: Foster creativity and digital literacy through AI-supported visual design aimed at improving comprehension of educational materials. (<https://www.beautiful.ai/player/-OHi1PHtU6m5KY1SoeXm>).

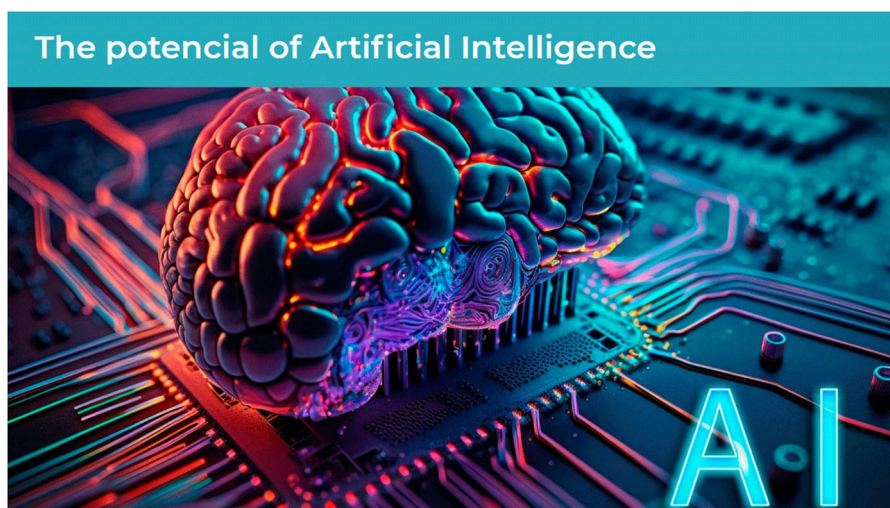


Figure 4. Presentation with Beautiful.AI: The potencial of artificial intelligence. Main educational objective: Promote critical reflection on the educational potencial of AI, fostering analytical thinking and the deliberate integration of technology into teaching practice. (<https://www.beautiful.ai/player/-OHi1GjPWxvXahMA8tNv>).

recommendations, a visually coherent and appealing presentation was achieved, aligned with best pedagogical practices. This facilitated the understanding of AI-related content, allowing students to access fundamental concepts of this discipline in a clear and effective manner.

To enrich the educational materials, QuizCube was used, a tool that allows for the automated creation of interactive quizzes to strengthen learning. The quizzes were developed based on the script generated with ChatGPT and the presentations from BeautifulAI (See Figure 4), aligning with the course content. Quizzes were implemented on topics such as Artificial Intelligence applied to education, educational laws in Spain, and current educational legislation (LOMLOE), facilitating the assessment of knowledge (See Figures 5–8). Additionally, QuizCube offers customization options that adapt to various teaching styles, and its intuitive interface promotes playful interaction, thereby increasing student retention and motivation

Depending on the desired visual style for the videos, two differentiated approaches were used:

Generation of realistic avatars: The use of Synthesia in the production of e-learning pills allowed for the creation of interactive visual content through realistic virtual avatars, powered by artificial

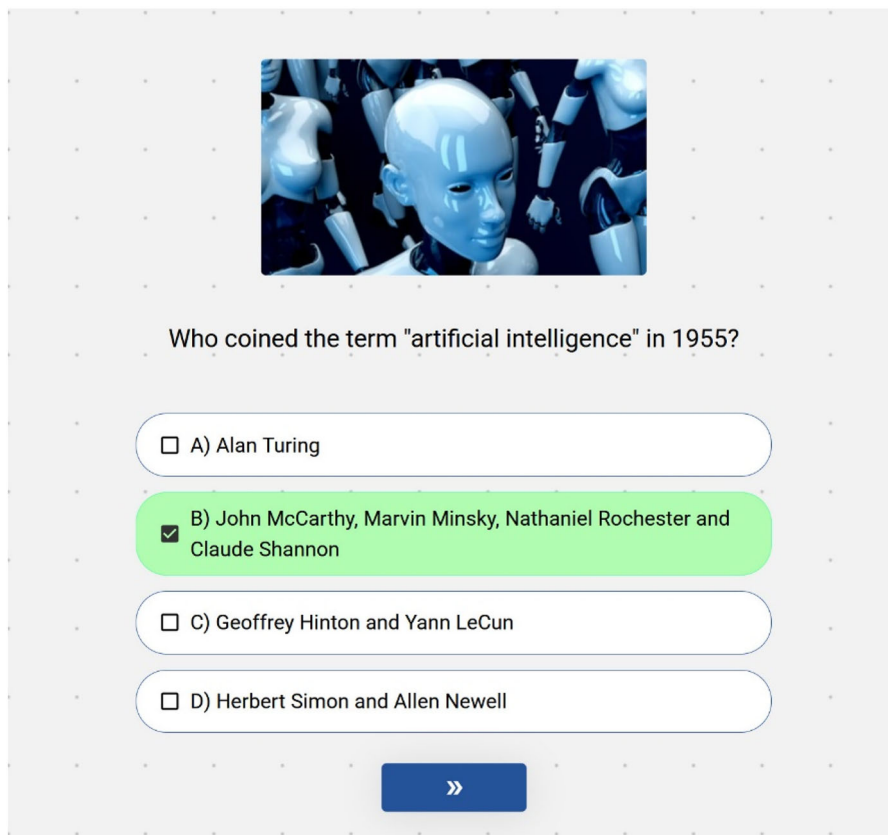
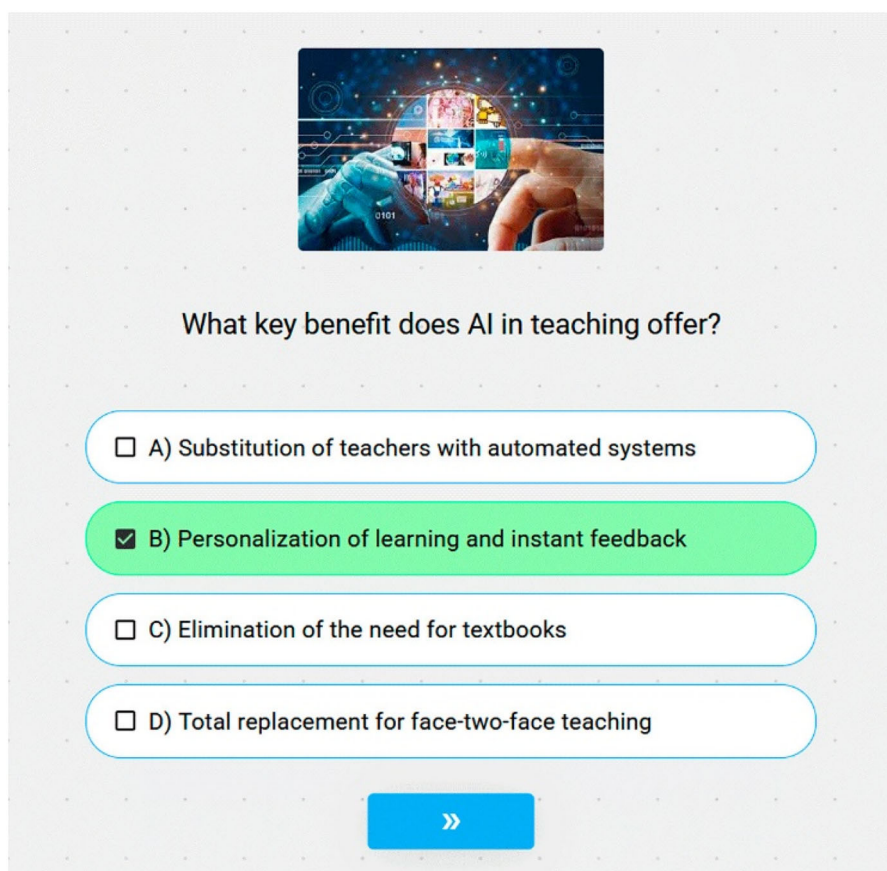


Figure 5. Basic issues about AI. Main educational objective: Reinforce the comprehension of foundational AI concepts through gamification and adaptive assessment strategies that foster dynamic, participatory, and motivating learning experiences. (<https://quiz.atlanticomedia.es/procesos-y-contextos-educativos-cuestiones-ba-638736794066822117>).

intelligence. This tool facilitated the explanation of complex concepts related to the Spanish LOMLOE educational law, presenting them in a clear and accessible way. The ability to customize educational materials, adapting them to specific pedagogical objectives, helped enhance students' understanding of educational regulations, increasing their motivation and promoting a more effective and engaging learning experience.

Generation of stylized avatars with video game aesthetics: For teaching the LOMLOE educational law, Convai was used in combination with Unreal Engine, a virtual character creation tool and a video game engine, respectively, to generate stylized avatars with a video game aesthetic. This approach allowed the integration of the script and educational materials into Convai, while video generation took place within the game engine, enabling greater customization and visual quality. The talking busts designed acted as dynamic presenters that introduced content about the LOMLOE, enhancing the learning experience through a more visual and engaging interaction compared to traditional methods (See [Figures 9](#) and [10](#)). This innovative approach promoted a deeper and more motivating understanding of legal content by the students.

Once the production of the e-learning pills was completed, they were uploaded to distribution platforms such as YouTube to facilitate access and dissemination among students. In order to optimize their reach and educational appeal, ChatGPT was used again to generate proposals for titles, descriptions, and metadata tailored to an engaging and accessible tone, maximizing the content's visibility. This tool, in addition to ensuring the coherence and clarity of the texts, helped improve the content's performance on search engines, making it easier for students to find. Thanks to its ability to personalize the content according to the platform's characteristics and the target audience, ChatGPT supported a more effective distribution, increasing student interaction and enhancing the pedagogical impact of the e-learning pills.



What key benefit does AI in teaching offer?

A) Substitution of teachers with automated systems

B) Personalization of learning and instant feedback

C) Elimination of the need for textbooks

D) Total replacement for face-two-face teaching


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Figure 6. AI applied to the classroom questionnaire. Main educational objective: Examine the role of AI in academic settings, encouraging critical reflection on learning personalization and real-time feedback mechanisms.(<https://quiz.atlanticomedio.es/procesos-y-contextos-educativos-cuestiones-ba-638736794066822117>).

This study has integrated artificial intelligence tools and advanced digital technologies in the creation, design, and distribution of educational materials, optimizing their production and facilitating their incorporation into the lesson planning of the course. The resources generated using AI were used in classroom sessions, allowing for the evaluation of their impact on students' understanding, retention, and application of knowledge. The use of tools such as ChatGPT, BeautifulAI, QuizCube, Synthesia, Convai, and Unreal Engine has automated complex tasks and improved the quality and efficiency of interactive educational materials, enriching the learning experience. The integration of these resources in the classroom has shown positive results in enhancing the understanding and retention of content, highlighting the effectiveness of artificial intelligence in education.

Statistical analysis

In this study, a comprehensive statistical analysis was conducted with the aim of validating the instrument, evaluating its reliability, comparing the scores obtained at the PRE and POST moments, and exploring the relationships between demographic variables and the questionnaire scores. First, a confirmatory factor analysis (CFA) was performed using Mplus (Version 8.3) to confirm the dimensional structure of the questionnaire, which consists of the cognitive, affective, and behavioral dimensions. The obtained Model Fit Statistics (e.g. an RMSEA below 0.09 and CFI and TLI values above 0.90) supported the adequacy of the model, in line with previous studies in the field (Suh & Ahn, 2022; Moral-Sánchez et al., 2023). Subsequently, IBM SPSS (Version 26) was used to evaluate the internal consistency of the instrument through Cronbach's Alpha coefficient for each dimension and for the total scale, with values exceeding 0.90 in most cases, indicating excellent reliability. Since normality tests (Kolmogorov-Smirnov) indicated that the data did not follow a normal distribution, the non-parametric Wilcoxon test for related



What level of teaching is subdivided into basic, intermediate and advanced in the Spanish education system?

Higher degree sports teachings

Higher degree FP

Language teaching

Preschool education

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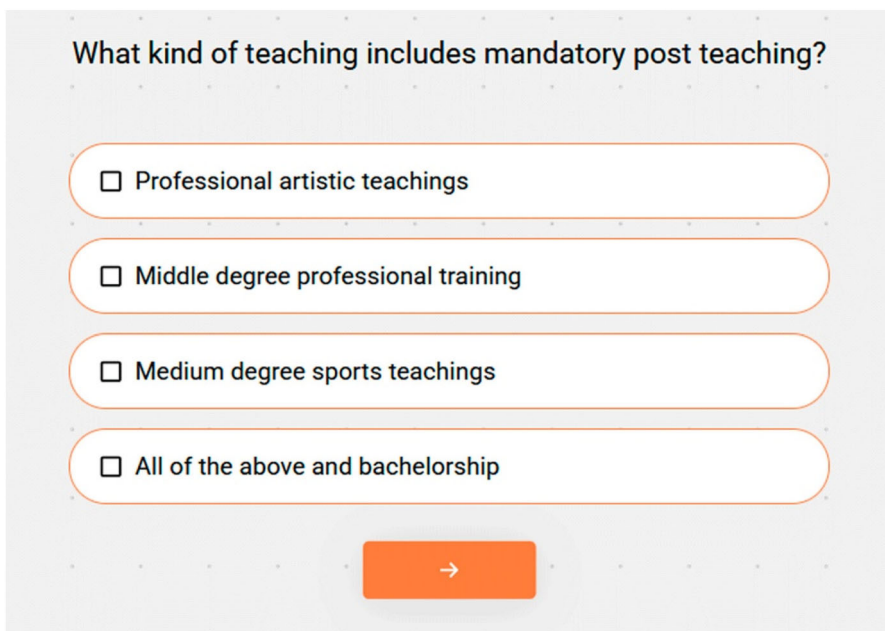
Figure 7. Spanish Educational Laws Questionnaire. Main educational objective: Understand the structure and regulations of the Spanish educational system through interactive quizzes that promote autonomous learning (<https://quiz.atlantico-medio.es/leyes-educativas-de-espana-638726166770309257>).

samples was used, allowing for a robust comparison of the PRE and POST scores and detecting significant differences after the intervention. Finally, the relationships between demographic variables (age, gender, academic level) and the scores for items and dimensions were analyzed, facilitating the identification of relevant associations that enrich the interpretation of the results based on the sample characteristics.

Results

Instrument validation

A confirmatory factor analysis (CFA) was conducted on the Pre intervention sample ($n = 242$) using the Weighted Least Square Mean and Variance Adjusted (WLSMV) estimator, which is suitable for ordinal data, to confirm the structure of the questionnaire, consisting of 21 items grouped into three dimensions (DIM1, DIM2, and DIM3). To evaluate the model fit (See Table 3), fit indices established in the literature were used. Chi-square value (χ^2) = 531.973 with 186 degrees of freedom ($p < 0.001$). χ^2/df ratio is approximately 2.86, which is acceptable (values ≤ 2 indicate good fit, and between 2 and 3 are acceptable; Schermelleh-Engel et al., 2003). Fit indices as RMSEA = 0.088 (90% CI: 0.079–0.096; values lower than 0.08 indicate good fit, although in this case it is considered acceptable; Steiger & Lind, 1980; Kline, 2015). CFI = 0.984 and TLI = 0.982 (values greater than 0.90 are acceptable, and values above



What kind of teaching includes mandatory post teaching?

Professional artistic teachings

Middle degree professional training

Medium degree sports teachings

All of the above and bachelorship

→

Figure 8. Basic questionnaire on the LOMLOE. Main educational objective: Help students better understand the LOMLOE through AI-supported self-assessment activities that facilitate practice, comprehension, and application of the learned content (<https://quiz.atlanticomedio.es/cuestionario-sobre-la-lomloe-638724520604825391>).

0.95 are excellent; Bentler, 1990; Tucker & Lewis, 1973; Hu & Bentler, 1999). And SRMR = 0.038 (values less than 0.08 indicate a good fit; Hu & Bentler, 1999; Chen et al., 2001).

Factor Loadings: The items show significant and robust loadings in their respective dimensions. For example, in DIM1 the loadings range from 0.832 to 0.909, in DIM2 from 0.835 to 0.941, and in DIM3 from 0.882 to 0.938. These values are consistent with the recommendations of Hair et al. (2010) and Kline (2015), as loadings greater than 0.70 indicate that each item explains at least 50% of the variance of the factor. These results confirm that the structure of the instrument, with three correlated dimensions, offers a psychometrically sound basis for our specific attitudinal assessment. The high factor loadings across dimensions indicate strong convergent validity, and all items exceeded the recommended threshold of 0.70 (Hair et al., 2010). Therefore, the scale can be considered a robust tool for capturing the cognitive, emotional, and behavioral dispositions of pre-service teachers toward GAI (see Figure 11).

These complete results confirm the validity and robustness of the instrument for assessing students' attitudes toward artificial intelligence tools.

Pre-post intervention analysis

A comparative analysis was conducted on the scores obtained in the PRE and POST evaluations in the sample of 180 participants, using the non-parametric Wilcoxon signed-rank test, as the normality tests (Kolmogorov-Smirnov) indicated that the data did not follow a normal distribution.

The analysis was carried out both for the global scale (Total Scale) and for each of the identified dimensions, which consist of the following items: DIM1 (Cognitive Dimension with Items 2 to 10), DIM2 (Affective Dimension with Items 11 to 15), and DIM3 (Behavioral Dimension with Items 16 to 22). Table 4 shows Cronbach's alpha values and the number of items for the PRE and POST evaluations. All subscales and the overall instrument demonstrated excellent internal consistency. Cronbach's alpha values were above 0.93 in both PRE and POST measurements, which is well above the conventional threshold of 0.70 (Tavakol & Dennick, 2011; Hair et al., 2010). Nonetheless, the high values observed in this study provide strong evidence of internal coherence and justify the use of the instrument for both cross-sectional and longitudinal comparison.



The LOMLOE in Spain

Principles and Educational Organization



Figure 9. Key points of the educational law in Spain (LOMLOE). Main educational objective: Facilitate audiovisual comprehension of complex legal content through AI-generated avatars that enhance motivation and interest. (<https://www.youtube.com/watch?v=sJpO9CKQWsw>).



Evolution of Education Laws in Spain

We explore the main education laws from the LGE of 1970 to the LOMLOE of 2020, highlighting their contributions to the Spanish education system.



Figure 10. Educational laws in Spain. Main educational objective: Promote critical digital and communication skills by using AI to optimize the dissemination and accessibility of academic materials in open digital environments (<https://www.youtube.com/watch?v=BYs73AITrT4>).

Hereafter, the descriptive and contrast results are as follows in [Table 5](#):

The Z and p values were derived from the Wilcoxon signed-rank test for related samples. It was observed that, with the exception of item 2 (whose difference did not reach significance, $p = 0.069$), all item comparisons, particularly the differences at the dimension and total scale levels, were statistically significant ($p < 0.01$).

Furthermore, the positive differences in the POST scores compared to the PRE scores indicate a favorable effect of the intervention. These findings support the effectiveness of the intervention in positively altering students' attitudes toward artificial intelligence.

Similarly, [Table 6](#) shows the distribution of responses for the variable that evaluated participants' preferences regarding various artificial intelligence tools after the intervention. It is observed that, out of a total of 180 responses, ChatGPT is the dominant choice with 44.4% of the mentions, followed by QuizCube with 27.2%.

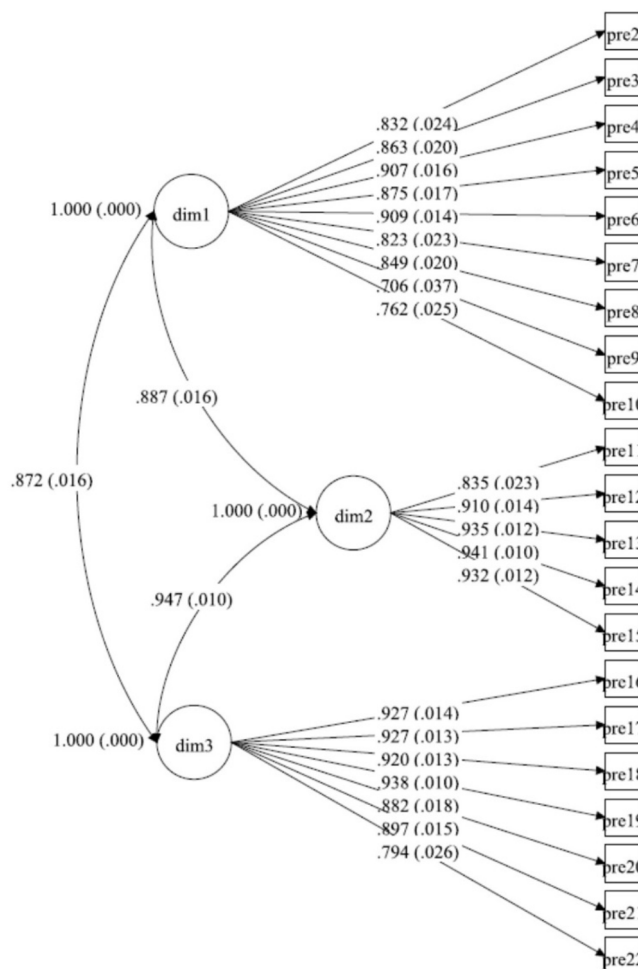


Figure 11. Factor loadings diagram for pre-intervention scale.

Correlation analysis

The relationships between demographic variables (age, gender, and educational level) and the scores of the items and dimensions of the questionnaire were examined using the Spearman correlation coefficient for ordinal data and non-parametric tests to compare differences between categories. The correlations between age and the different dimensions were not statistically significant (DIM1; $\rho = 0.124$, $p = 0.097$; DIM2: $\rho = 0.103$, $p = 0.169$; and DIM3: $\rho = 0.047$, $p = 0.535$).

Mann-Whitney tests were conducted to compare the distributions of the items and dimensions between gender categories. In general, these tests indicated that most items and all dimensions showed no significant differences between genders. Kruskal-Wallis test was used to evaluate the differences based on the educational level (Bachelor's, Master's, and PhD). The hypothesis tests showed that the distribution of scores for almost all items and dimensions was similar across categories, suggesting that the educational level does not significantly affect the evaluated attitudes.

Additionally, confirmatory multivariate analyses (using Wilks' Lambda) were conducted to evaluate the joint effect of demographic variables (age, gender, and educational level) and their interactions. These analyses did not yield significant effects ($p > 0.05$), affirming that, collectively, the demographic variables do not explain substantial variations in the questionnaire scores.

Discussion

The findings of this study highlight the transformative role that the integration of Generative Artificial Intelligence tools can have in the university educational environment, particularly in the

Table 3. Model fit statistics.

Index	Value	Interpretation
Chi-square (χ^2)	531.973	$p < 0.001$; $\chi^2/df \approx 2.86$ (acceptable)
RMSEA	0.088	IC 90%: 0.079–0.096 (acceptable)
CFI	0.984	Excellent (values > 0.95)
TLI	0.982	Excellent (values > 0.95)
SRMR	0.038	Excellent (values < 0.08)

Table 4. Reliability of the scales (Cronbach's alpha).

Evaluation	Scale/subdimension	Number of items	Cronbach's alpha
PRE	Total Scale	21	0.975
	DIM1	9	0.938
	DIM2	5	0.943
	DIM3	7	0.950
POST	Total Scale	21	0.975
	DIM1	9	0.951
	DIM2	5	0.941
	DIM3	8	0.943

Table 5. Comparison of PRE and POST scores by dimension.

Scale/dimension	PRE (mean \pm SD)	POST (average \pm SD)	Difference (average)	Z	p-value
Total scale	4.2444 \pm 0.9819	4.8219 \pm 0.8490	0.5776	-7.801	<0.001
DIM1	5.0780 \pm 0.8000	5.3070 \pm 0.7500	0.2290	-5.102	<0.001
DIM2	5.0378 \pm 0.9480	5.3218 \pm 0.7563	0.2840	-4.500	<0.001
DIM3	4.9738 \pm 0.8879	5.2453 \pm 0.7715	0.2715	-4.516	<0.001

Table 6. Preference for artificial intelligence tools.

AI tool	Frequency	Percentage (%)
Beautiful. ai	19	10,6
ChatGPT	80	44,4
Convai	12	6,7
Neiro	10	5,6
QuizCube	49	27,2
Synthesia	10	5,6
Total	180	100

perception of future educators during their training stage. The empirical evidence obtained supports the effectiveness of incorporating digital resources, such as ChatGPT, Beautiful.ai, QuizCube, Convai, and Synthesia, into teacher training to promote responsible use, thereby enhancing the teaching-learning process, aligning with recent literature on digital transformation in education (Chan & Hu, 2023; Huang et al., 2023).

First, the robust measurement instrument developed, based on the Suh and Ahn (2022) scale and adapted to our context, demonstrated outstanding reliability and validity indices. This ensures that the cognitive and affective dimensions are captured accurately, corroborating previous studies that emphasize the importance of having validated instruments to assess attitudes toward AI (Moral-Sánchez et al., 2023; Nartey, 2024; Parveen & Alkudsi, 2024).

After validating the questionnaire, the results of comparing the scores obtained at the PRE and POST stages in our sample showed significant improvements in perceptions across the cognitive, affective, and behavioral dimensions, supporting the effectiveness of the intervention in positively modifying attitudes toward AI in teacher training. Importantly, these improvements suggest that short-term interventions incorporating generative AI can shift learners' beliefs, emotions, and intentions toward pedagogical innovation. Yet, given the cross-sectional nature of our design, we cannot ascertain whether these attitudinal shifts will persist in the long term. Longitudinal studies, such as those employing a four-wave model of attitude change (Cvetkovic et al., 2025), would be needed to explore the durability of these effects.

Digging into each dimension, the cognitive gains reflect a deeper understanding of AI's role in education, aligning with the concept of AI literacy that emphasizes not only knowledge but also evaluative and ethical dimensions (Du et al. (2024; Pinski & Benlian, 2024). The affective improvements, increased

interest, enthusiasm, and confidence, are encouraging, but the data also caution us to consider negative affective responses such as anxiety, skepticism, or even over-dependence. Some participants indeed mentioned discomfort in trusting AI outputs or fear of reduced human agency, echoing findings in the literature about affective barriers in adopting AI (Krause et al., 2025; Lin & Chen, 2024). Therefore, teacher education programs must incorporate strategies that help future teachers manage such emotional tensions. Behaviorally, the greater intention to use AI-based digital resources post-intervention suggests that the intervention succeeded in bridging the gap between perception and intended practice. However, actual adoption in larger educational scale settings may differ. This gap between intention and action is well-known in technology adoption research and underscores the need for follow-up research.

The correlation analysis revealed that demographic variables such as age, gender, and academic level have minimal influence on students' attitudes. This finding is consistent with previous research that has indicated that, in specific educational contexts, technological interventions can generate homogeneous effects regardless of participants' individual characteristics (Ajzen, 1991).

On the other hand, the implementation of generative AI technologies has fostered a more interactive and personalized learning environment, facilitating the adaptation of content to the individual needs of students (Sajja et al., 2024). This ability to personalize is crucial for preparing future professionals for the challenges of an increasingly digital and competitive job market (Bahroun et al., 2023; Martínez-Ruiz, 2019).

Turning to limitations, although purposive sampling allowed us to recruit a relatively homogeneous group relevant to the educational context (Hernández-Sampieri & Mendoza, 2020), this approach limits the generalizability of results beyond this Master's cohort in Spain. Institutional culture, curriculum norms, and local attitudes toward AI may vary significantly in other contexts. Furthermore, while our study provides valuable insights for teacher training, the lack of longitudinal follow-up means we cannot confirm the sustainability over time of positive attitudinal change, a key area for future inquiry.

Also in terms of practical implications for teacher training curricula, our findings support the incorporation of modules on AI literacy that go beyond technical familiarity to include ethical reasoning, prompt design, data stewardship, and critical evaluation of AI outputs. Training should scaffold from guided exposure to hands-on, reflective use of generative AI, ideally in a co-discovery or inquiry-based format (as described in recent AI literacy research). Programs should balance innovation with risk by fostering critical attitudes, awareness of bias, and reflexivity about automation vs human agency. By attending to affective risks (e.g. anxiety, distrust) alongside cognitive and behavioral goals, teacher preparation can more holistically support future educators in using AI conscientiously.

These findings align with previous research indicating that the integration of AI in higher education has a multidimensional impact, improving academic performance and cognitive skills through the personalization and adaptability of its tools (Jaboob et al., 2025). AI literacy and the development of digital competencies are essential for effective and informed adoption (Hamamra et al., 2025; Ma & Lei, 2024). Furthermore, fostering a critical and reflective attitude will enable responsible pedagogical use, preventing an uncritical dependence on these technologies (Al-Mughairi & Bhaskar, 2025). Only through continuous teacher training and an ethical approach will it be ensured that AI contributes to equitable and sustainable education.

Conclusions

The findings of this study highlight the transformative role that the integration of Generative Artificial Intelligence tools can have in the university educational environment, particularly in the perception of future educators during their training stage. The intervention achieved significant attitudinal shifts across cognitive, affective, and behavioral dimensions, underscoring the promise of structured exposure to generative AI in teacher education. Yet, these results reflect short-term change, and their persistence over time remains untested. Given the study's context, a single Master's program in Spain, caution is warranted in generalizing to other educational systems or cultural settings. To translate these findings into practice, teacher education programs should embed AI literacy curricula that integrate technical skills

with ethical, affective, and critical reflection components. Educators must be equipped not only to harness AI but to question, challenge, and govern its use. Future research should adopt longitudinal designs and diverse samples to examine long-term sustainability and cross-context validity. So, while generative AI holds great promise as a pedagogical catalyst, its responsible integration demands a holistic approach, one that cultivates digital competence, critical agency, moral discernment, and emotional resilience in future teachers.

Authors' contributions

Carrión Candel: conceptualization, interventions, original draft, review. Lomba Pérez: development and writing descriptions of AI tools, interventions. Berd-Gómez: methodology, statistics, formal analyses, original draft, review. González-Martín: methodology, writing, review, translation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethical statement

This research was conducted in accordance with the highest ethical standards. All participants provided written informed consent, and confidentiality was strictly maintained. The study complied with all institutional and national ethical guidelines, ensuring that no harm or distress was caused to participants. The study was approved the Ethics Committee of the University *Universidad del Atlántico Medio* under protocol number CEI/01-017.

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About the authors

All authors belong to Universidad del Atlántico Medio (UNAM) group 'Experiencias Lúdicas con Inteligencia Artificial y Tecnología Educativa (ELITE)'. It's an emerging research group that promotes educational innovation and teacher training through the use of digital technologies and Artificial Intelligence. Its approach combines active methodologies and Gamification to enrich learning in higher education. Among its objectives are the development of digital resources, the analysis of perceptions on the Sustainable Development Goals (SDGs) and the exploration of the educational potential of Artificial Intelligence.

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Data availability statement

All data supporting the findings of this study are contained within the article. In addition, the full dataset will be uploaded to the Open Science Framework (OSF) and made publicly available upon publication.

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