

Competencias pedagógicas y conocimientos técnicos para el uso responsable de herramientas de inteligencia artificial generativa: Evidencia de una intervención formativa con futuros pedagogos

Pedagogical Competences and Technical Knowledge for the Responsible Use of Generative Artificial Intelligence Tools: Evidence from a Training Intervention with Future Pedagogues

Francisco David Guillén-Gámez
Universidad de Málaga
davidguillen@uma.es

Akhmad Habibi
Universitas Jambi, Indonesia
akhmad.habibi@unja.ac.id

María Belén Morales-Cevallos
Faculty of Marketing and Communication, Universidad Ecotec, Via Principal Campus Ecotec Km 13.5, Samborondón 092302, Ecuador
mmoralesc@ecotec.edu.ec

Noelia Pellicano-Piris
Departamento Ciencias de la Educación, Universidad Rey Juan Carlos
noelia.pellicano@urjc.es

RESUMEN

La creciente presencia de la Inteligencia Artificial (IA) y de la Inteligencia Artificial Generativa (IAGen) en los contextos educativos requiere que los futuros profesionales de la educación desarrollen tanto competencias pedagógicas como conocimientos técnicos. Este estudio examina las competencias autopercebidas del estudiantado de Pedagogía en relación con el uso educativo de herramientas de IAGen. En concreto, analiza sus niveles antes y después de una intervención formativa universitaria, así como posibles diferencias según el sexo y su relación con la motivación académica y la creatividad autopercebida. Se implementó un diseño cuasiexperimental pretest-postest con 112 estudiantes de Pedagogía de la Universidad de Málaga. El estudio evaluó tres dimensiones: competencias pedagógicas para la creación de materiales

ARTÍCULOS



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con herramientas de IAGen, competencias pedagógicas para la planificación de actividades de aprendizaje con estas herramientas y conocimientos técnicos sobre IAGen. Los datos se recogieron mediante un instrumento de autoinforme validado. Los resultados mostraron niveles iniciales moderados de competencias pedagógicas y niveles comparativamente más bajos de conocimientos técnicos antes de la intervención. Tras la experiencia formativa, se observaron mejoras estadísticamente significativas en todas las dimensiones, con tamaños de efecto elevados, especialmente en el conocimiento técnico. No se encontraron diferencias significativas según el sexo. La motivación académica mostró una relación limitada con el desarrollo de estas competencias, mientras que la creatividad autopercebida en el diseño de actividades digitales se relacionó positivamente con varias dimensiones competenciales. Estos hallazgos ponen de manifiesto la importancia de integrar la formación en herramientas IAGen en los programas de educación superior para favorecer el desarrollo de competencias pedagógicas y técnicas en los futuros profesionales de Pedagogía.

PALABRAS CLAVE

Inteligencia artificial generativa; competencia digital; competencias pedagógicas; futuros pedagogos; formación docente; intervención formativa; alfabetización en IA; pretest; posttest.

ABSTRACT

The growing presence of Artificial Intelligence (AI) and Generative Artificial Intelligence (GenAI) in educational contexts requires future education professionals to develop both pedagogical competences and technical knowledge. This study examines pedagogy students' self-perceived competences related to the educational use of GenAI tools. Specifically, it analyses their levels before and after a university training intervention, as well as potential differences according to sex and the relationship with academic motivation and self-perceived creativity. A quasi-experimental pretest–posttest design was implemented with 112 pedagogy students at the University of Málaga. The study assessed three dimensions: pedagogical competences for creating materials with GenAI tools, pedagogical competences for planning learning activities with GenAI tools, and technical knowledge of GenAI. Data were collected through a validated self-assessment instrument. The results revealed moderate initial levels of pedagogical competences and comparatively lower levels of technical knowledge prior to the intervention. After the training experience, statistically significant improvements were observed across all dimensions, with large effect sizes, particularly in technical knowledge. No significant differences were found according to sex. Academic motivation showed limited associations with competency development, whereas self-perceived creativity in designing digital activities was positively related to several competency dimensions. These findings highlight the importance of integrating training on GenAI tools into higher education programmes to support the development of pedagogical and technical competences among future pedagogy professionals.

KEYWORDS

Generative artificial intelligence; digital competence; pedagogical competences; pre;service pedagogues; teacher education; training intervention; AI literacy; pretest; posttest.

I. INTRODUCTION

One of the most significant technological transformations of the 21st century is the rapid advancement of artificial intelligence (AI), particularly generative artificial intelligence (GenAI) (Krisnhan et al., 2025; Mohamed et al., 2025; Moral-Sánchez et al., 2023). The emergence of tools such as ChatGPT since late 2022 has accelerated the diffusion of GenAI technologies capable of producing human-like text, images, code, and interactive content (Foung et al., 2024; Guillén-Gámez et al., 2025). In educational contexts, these developments are increasingly viewed as transformative, as AI can automate complex tasks, optimise educational processes, and support decision-making in teaching and learning environments (Singh, 2023).

In particular, GenAI holds considerable potential to enhance educational practices by enabling personalised learning experiences, providing real-time feedback, and supporting collaborative and culturally responsive learning activities (Öncü et al., 2026; Almazán-López et al., 2025). In addition, these technologies can facilitate the individualisation of teaching and learning strategies according to students' needs and preferences (Hashim et al., 2022). A wide range of AI-based tools, including Microsoft Copilot, Gemini, Midjourney, Synthesia, and HeyGen, already support educators in creating instructional materials, producing multimedia resources, translating content, and adapting learning experiences to diverse student profiles (Baskar, 2025; Contreras et al., 2024).

This technological advance requires educators to rethink their professional roles. Traditional responsibilities centred on information transmission are increasingly shifting toward facilitation, curation, ethical guidance, and the orchestration of AI-augmented learning environments (Rani et al., 2025; Wajeed, 2025). In this context, teachers need to develop the pedagogical competences required to integrate GenAI tools effectively into teaching and learning processes (de la Flor Bancalero et al., 2026). At the same time, the use of generative AI tools among students is rapidly increasing. Recent studies show that higher education students frequently use applications such as ChatGPT and other AI-based systems for tasks including information search, content generation, and academic writing support (Radiowala, 2024; Stöhr et al., 2024). Consequently, educators must be prepared not only to use these technologies themselves but also to guide students in their effective, critical, and responsible use within educational contexts. However, teacher preparation has not evolved at the same pace. Previous studies have identified important challenges in teacher preparation for the integration of artificial intelligence in educational contexts. For instance, Meylani (2024) highlights "a gap in teacher preparedness, particularly in developing AI literacy and integrating AI tools into classroom practices" (p. 600). As a result, many in-service and pre-service teachers report uneven implementation and difficulties leveraging these technologies for pedagogical innovation (Heine & König, 2025).

While these competences are relevant for all teachers, they are particularly critical for future pedagogues, who frequently play advisory, curriculum development, and educational innovation roles within educational systems (Memon & Kwan, 2025). Pedagogy programmes typically prepare students to analyse educational systems, design educational interventions, and contribute to curriculum development across different institutional contexts (Altuna et al., 2021). For this reason, developing both pedagogical skills for integrating GenAI into teaching practices and technical knowledge about AI concepts, privacy protection, and troubleshooting is essential (Giannakos et al., 2025). A growing body of literature has examined pre-service teachers' perspectives, attitudes, and AI literacy (Karaduman, 2025; Tunjera & Chigona, 2025; Gamlem et al., 2026). These studies reveal mixed perceptions: optimism regarding the potential of GenAI for lesson planning and material creation (Heng et al., 2026), alongside concerns related to ethical issues, overreliance, and the potential impact on critical thinking (Szmyd & Mitera, 2024; Rehmat et al., 2025).

Despite the growing body of research on GenAI in teacher education, most studies have focused on perceptions, attitudes, or general AI literacy (Alieto et al., 2024). In contrast, this study contributes by providing empirical evidence on the development of pedagogical competences and technical knowledge through a training intervention. Furthermore, it adopts a multidimensional

approach that simultaneously examines material creation, instructional planning, and technical knowledge, and extends prior research by focusing on future pedagogues. More specifically, this study advances the literature by analysing the relationship between self-perceived creativity in the design of digital materials and the development of GenAI competences, an aspect that still has received limited empirical attention. In addition, it examines the role of academic motivation to continue learning and its influence on GenAI competences.

Accordingly, the present study addresses the following research questions: (1) What are pedagogy students' self-perceived pedagogical competences and technical knowledge related to the use of GenAI tools before and after a training intervention? (2) Are there significant differences in these competences after participation in the intervention? (3) Do these competences differ according to students' sex? (4) What relationships exist between students' academic motivation and their competences related to the use of GenAI tools? (5) What relationships exist between students' self-perceived creativity in designing digital activities and their competences related to the use of GenAI tools?

2. RELATED WORKS

Recent research has begun to examine how training programmes can support the development of competences related to the use of GenAI tools in teacher education. Moorhouse et al. (2024) conducted a study in Hong Kong with 54 pre-service language teachers enrolled in a Master's programme in English Language Teaching. An eleven-week training intervention was implemented to develop professional competences related to the pedagogical use of GenAI tools. The results showed that explicit training contributed to improving participants' technological proficiency and their pedagogical use of these tools, particularly in lesson planning and the creation of teaching materials. However, some competences showed more limited development, such as the ability to guide students in the responsible and critical use of GenAI tools. Similarly, Oh (2025) examined the use of GenAI tools based on text-to-video technology in pre-service teacher education in South Korea. The study involved 34 future teachers and used a pretest-posttest design. The findings revealed significant improvements in several pedagogical competences, particularly in the selection of educational materials and lesson planning. In a related study, Huang et al. (2025) analysed the development of GenAI literacy among pre-service language teachers at a university in China. The study involved 90 students enrolled in a teacher education course and examined the impact of integrating GenAI tools into a 12-week training programme. The results showed significant improvements in overall GenAI literacy and in several dimensions, including technical proficiency, critical evaluation, communication with AI systems, creative application, and ethical competence. However, the study focused specifically on language teachers and did not analyse pedagogical competences related to the broader educational use of GenAI tools. In the same context, Lu et al. (2024) analysed the impact of GenAI tools in the training of future teachers of mathematics, science, and technology at a Chinese university. The study included 215 students and applied a quasi-experimental pretest-posttest design. The results indicated that students who used GenAI tools during training achieved significantly higher levels of teacher self-efficacy and higher-order thinking skills than those who followed a traditional training approach. In this context, the present study contributes to this emerging line of research by analysing the development of pedagogical competences and technical knowledge related to GenAI tools among pre-service pedagogues in the territorial Spanish.

Several studies have examined whether differences exist according to sex in relation to AI competences, literacy, or attitudes among pre-service teachers. For instance, Balasa (2025) analysed AI literacy, readiness-confidence, and acceptance among 384 pre-service teachers in Philippine higher education institutions and found significant differences according to sex, with male students obtaining slightly higher scores than female students, although with small effect sizes. Similarly, Dumagay (2025), in a study with 378 pre-service teachers from public universities in the Philippines, reported significant differences according to sex, where male students showed higher levels of AI literacy and lower levels of anxiety, while female students presented

slightly higher anxiety but somewhat more positive attitudes toward AI. In a cross-cultural study involving 605 pre-service teachers from universities in Germany and Türkiye, Aksoy et al. (2026) also identified significant sex differences in AI literacy, particularly in the dimension related to technical understanding, with higher scores among male students. In contrast, Merzifonluoglu & Gunes (2025) found that female students displayed more positive attitudes towards AI than their male counterparts; however, their study focused on attitudes rather than pedagogical competences or conceptual knowledge. Other studies have reported no significant differences according to sex. For example, Cetin & Celen (2025), analysing AI literacy and perceptions of its educational use among 323 pre-service teachers in Türkiye, did not find statistically significant differences between male and female students. In a related context, Lee & Zhai (2024) examined how pre-service teachers integrated GenAI tools such as ChatGPT into science lesson planning and reported significant differences according to sex in confidence levels when using GenAI tools, with higher confidence among male participants.

The adoption of digital technologies can also be influenced by hedonic motivation, defined as the pleasure or enjoyment a person experiences when using a particular technology (Venkatesh et al., 2012). According to Salifu et al. (202), this type of motivation is related to the satisfaction generated by using technological tools, which can transform an initially instrumental task into a more engaging and rewarding experience. In educational contexts, this motivation may not only be linked to the use of GenAI tools but also to the interest in learning how to use them for pedagogical purposes, such as creating educational materials, planning learning activities, or understanding concepts related to AI. In this line, previous research has shown that hedonic motivation positively influences students' intention to use AI-based technologies, such as chatbots (De Blanes Sebastián et al., 2022; Acosta-Enriquez et al., 2025). However, there is still a lack of studies that specifically examine how this type of motivation toward learning and using AI technologies is related to the development of pedagogical competences for creating teaching materials, planning learning activities, or acquiring conceptual knowledge about AI. Therefore, further research is needed to explore this relationship in the context of initial teacher education.

Creativity is considered one of the key competences for teachers in the 21st century (Newton & Newton, 2014; Guillén-Gámez et al., 2024), as it allows them to face changing educational contexts and develop innovative solutions to problems in teaching practice (Cho et al., 2017). In addition, teachers need to be creative to design learning environments that also foster students' creativity (Hung & Sitthiworachart, 2020). In this regard, recent research has shown that educational environments supported by AI can contribute to the development of students' creativity and improve their learning outcomes (Wang et al., 2023). However, there is still limited empirical evidence examining the relationship between self-perceived creativity in designing activities with digital technologies and the development of pedagogical competences related to the use of GenAI tools.

Considering the reviewed scientific literature, only a limited number of studies have focused on the development of pedagogical competences and technical knowledge related to GenAI tools in the initial training of education professionals. Although research on the use of these technologies in educational contexts has increased in recent years, most studies have mainly examined teachers' or pre-service teachers' perceptions, attitudes, or intentions to use GenAI, rather than the development of specific competences for their pedagogical integration. In addition, limited empirical evidence has analysed the impact of training experiences specifically designed to strengthen these competences in future education professionals. Likewise, there is still scarce research exploring how individual factors such as academic motivation or creativity may relate to the development of competences associated with the educational use of GenAI tools. In this context, the present study contributes to the literature by providing empirical evidence on the development of pedagogical competences and technical knowledge through a training intervention. Furthermore, it examines the relationship between self-perceived creativity in the design of digital materials and the development of GenAI competences, as well as the role of academic motivation to continue learning and its influence on these competences. Based on this context, the following research objectives are proposed:

O1. To describe pedagogy students' self-perceptions of their pedagogical competences and technical knowledge related to GenAI tools in the pretest and posttest stages.

O2. To analyse whether significant differences exist in pedagogical competences and technical knowledge related to GenAI tools between the pretest and the posttest after the training intervention.

O3. To determine whether differences exist in pedagogical competences and technical knowledge related to GenAI tools according to students' sex.

O4. To analyse the relationship between self-perceived academic motivation and pedagogical competences and knowledge related to GenAI tools.

O5. To examine the relationship between self-perceived creativity in designing activities with digital technologies and pedagogical competences and knowledge related to GenAI tools.

Based on the research objectives proposed, the following hypotheses were formulated:

H1. Pedagogy students will show significant differences in their pedagogical competences and technical knowledge related to GenAI tools between the pretest and the posttest after the training intervention.

H2. Differences will exist in pedagogical competences and technical knowledge related to GenAI tools according to students' sex.

H3. Self-perceived academic motivation will be related to the level of pedagogical competences and knowledge related to GenAI tools.

H4. Self-perceived creativity in designing activities with digital technologies will be related to pedagogical competences and knowledge related to GenAI tools.

3. METHOD

3.1 Design and participants

The study was conducted using a quasi-experimental design with pretest-posttest measures in a single group, with the aim of analysing changes in pedagogical competences and technical knowledge related to the use of GenAI tools after participation in a training intervention. The sample consisted of 112 university students enrolled in the Pedagogy degree programme, who were taking the fourth-year course "ICT as a Support for Educational Innovation" at the Faculty of Education Sciences of the University of Málaga. Regarding the academic year, 56.30% of the students belonged to the 2024–2025 cohort, while 43.80% corresponded to the 2025–2026 cohort. In terms of sex, 72.30% of the sample ($n = 81$) were women and 27.70% ($n = 31$) were men. Furthermore, most students (81.30%; $n = 91$) reported that they had not participated in any training course related to educational technology during the previous year, whereas 18.70% ($n = 21$) indicated that they had previously taken part in this type of training.

3.2 Procedure and Programme Description

The training intervention was implemented within the course "ICT as a Support for Educational Innovation", which is part of the Pedagogy degree programme at the Faculty of Education Sciences of the University of Málaga, during the first semester of the academic year (September–January). Within this course, students participated in an educational innovation project using ICT, in which the use of GenAI tools was progressively integrated throughout the different sessions of the course.

The project consisted of designing an educational innovation proposal aimed at addressing a training need identified in an educational, socio-community, or socio-professional context. For this purpose, students, organised in groups, were required to analyse a specific problem, support their proposal with scientific evidence, and design an instructional plan based on the identified training needs through the use of innovative digital educational resources addressed to the selected target group. The final outcome of the project was presented in a website created with Google Sites, where all stages of the process were compiled, from the initial needs analysis to the presentation of the educational resources developed.

The development of the project was organised into several training phases in which the use of GenAI tools was integrated to support research tasks, content generation, visual design, and the creation of digital educational resources.

In the first phase, focused on the introduction and problem definition, each group was required to identify a training need in an educational, socio-community, or socio-professional context and to develop a justification supported by scientific evidence. At this stage, several GenAI tools were used to support academic writing and the analysis of scientific information, such as ChatGPT, Microsoft Copilot, and Gemini, as well as tools designed to facilitate the reading and understanding of scientific articles, including SciSpace and ChatPDF. In the following phase, related to the definition of expected results and the scientific foundation of the project, students conducted searches and analyses of academic literature in order to justify the relevance of their educational innovation proposal. For this purpose, GenAI tools oriented to scientific research, such as Consensus, SciSpace, and ChatPDF, were used to help identify relevant empirical evidence. In a later phase, focused on the visual identity of the project, each group was required to design a logo representing their educational innovation proposal. For this task, image generation tools based on GenAI, such as Midjourney, Bing Create, Canva AI, and Microsoft Designer, were used. During the phases dedicated to the creation of digital educational resources, students developed audiovisual materials and interactive activities addressed to the selected target group. In particular, short educational videos were produced using AI-based video generation tools, such as HeyGen, Synthesia, and Renderforest. In addition, tools for automatic dubbing and subtitle generation, such as Rask.ai, were used to translate the videos into different languages and improve accessibility. Finally, several GenAI-supported applications for multimedia presentations, including Sendsteps.ai, Slidesgo AI, Gamma, and Canva, were introduced to support the presentation of the projects.

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Table 1. provides a summary of the main phases of the project and the GenAI tools used in each stage.

Project phase	Description	AI tools used
Project planning	Organisation of group work and distribution of tasks through digital project management tools.	Trello / Asana
Introduction and problem definition	Identification of a training need and development of the academic justification supported by scientific literature.	ChatGPT, Copilot, Gemini, SciSpace, ChatPDF
Needs analysis (SWOT)	Analysis of strengths, weaknesses, opportunities and threats related to the selected context.	GenAI tools used as support for information synthesis
Expected results and scientific grounding	Review of scientific literature to justify the potential impact of the proposed innovation.	Consensus, SciSpace, ChatPDF
Definition of learning objectives	Formulation of educational objectives aligned with the detected needs.	Generative AI tools for text support
Project visual identity	Creation of the project logo and visual identity.	Midjourney, Bing Create, Canva AI, Microsoft Designer
Creation of audiovisual learning resources	Development of short educational videos (“learning pills”) explaining key contents.	HeyGen, Synthesia, Renderforest
Translation and accessibility of videos	Automatic dubbing and subtitle generation in different languages.	Rask.ai
Multimedia presentations	Creation of interactive presentations to communicate the project results.	Sendsteps.ai, Slidesgo AI, Gamma, Canva

Note: Own elaboration.

Before the training intervention began, the pretest questionnaire was administered to assess students’ pedagogical competences and technical knowledge related to the use of GenAI tools. After the training experience had been completed and the projects had been presented, the instrument was administered again (posttest) in order to analyse the changes that occurred after the intervention.

3.3 Instrument description

To address the objectives of the study, the instrument “GenAI Competency Self-Assessment Scale for Pre-Service Educators” was used. This instrument was designed to assess students’ self-perceptions of pedagogical competences and technical knowledge related to the use of GenAI tools in educational contexts. The instrument is structured into three theoretical dimensions: (1) PCAI-CM (Pedagogical competences with GenAI for Creating Materials), which focuses on the ability to design educational materials using GenAI tools; (2) PCAI-PT (Pedagogical competences with GenAI for Planning Tasks), related to instructional planning and the personalisation of learning with the support of GenAI tools; and (3) TK-AI (Technical Knowledge about GenAI), which refers to the technical, conceptual, and ethical knowledge associated with the educational use of GenAI. After the factorial refinement process, the scale consisted of 10 items, assessed using a seven-point Likert-type scale, where 1 corresponded to “I am not able to do it at all” and 7 to “I can do it easily on my own.”

The psychometric properties of the instrument were verified following the steps followed in similar studies (Romero Martínez et al., 2020; de la Flor-Bancalero & Guillen-Gamez, 2025; Guillén-Gámez et al., 2026). Regarding the internal consistency of the instrument, reliability was assessed using Cronbach’s alpha coefficient, obtaining an overall value of .833 in the pretest and .842 in the posttest, indicating satisfactory reliability. The psychometric properties of the instrument were also examined through an exploratory factor analysis (EFA). First, the adequacy of the data was verified. The Kaiser–Meyer–Olkin (KMO) index reached a value of .769, which is considered acceptable, and the Bartlett’s test of sphericity was statistically significant ($\chi^2 = 927.436$; $df = 45$; $p < .001$), confirming that the correlation matrix was suitable for factor analysis. The EFA was conducted using the maximum likelihood method, with an oblimin rotation and Kaiser normalization, assuming correlations among factors. The factorial solution converged after five iterations and revealed a three-factor structure with eigenvalues greater than 1, which explained 42.68%, 19.86%, and 17.44% of the variance, respectively. Overall, the three factors explained 79.98% of the total variance, indicating a high explanatory capacity of the model.

This three-factor structure was also confirmed through a confirmatory factor analysis (CFA) using the maximum likelihood method. The fit indices indicated an adequate correspondence between the theoretical model and the observed data, following the recommendations of Bentler (1989) and Hu and Bentler (1999): $\chi^2 = 124.698$ $df = 34$; $p = .000$; $CMIN/df = 3.668$; $IFI = .902$; $CFI = .901$; $TLI = .914$. In addition, convergent and discriminant validity were supported, as all dimensions showed composite reliability (CR) values above .80 and average variance extracted (AVE) values above .50. Furthermore, the criterion for factor discrimination ($MSV < AVE$) was satisfied, as shown in Table 2.

Table 2. Convergent and discriminant validity.

Factors	CR	AVE	MSV	Square root of AVE (diagonal) and Correlations between factors		
				PCAI-CM	PCAI-PT	TK-AI
PCAI-CM	.801	.625	.385	.791		
PCAI-PT	.931	.777	.402	.291**	.882	
TK-AI	.837	.631	.302	.132	.320**	.794

Note: Own elaboration. *** $p < .001$

3.4 Data analysis techniques and procedures

The statistical techniques used in this study were selected according to each of the research objectives proposed:

- For O1, descriptive analyses were conducted by calculating measures of central tendency (mean) and dispersion (standard deviation) for the items and dimensions of the instrument.
- For O2, differences between the pretest and posttest scores after the training intervention were analysed. Before conducting the comparisons, the assumption of normality was examined through the analysis of skewness and kurtosis indices and the corresponding normality tests. Since several dimensions did not meet the normality assumption, the Wilcoxon signed-rank test was applied. To estimate the magnitude of the observed effects, the effect size (r) was calculated using the formula: $r = |Z| / \sqrt{N}$, where Z corresponds to the standardized test statistic and N to the number of valid paired observations (Rosenthal, 1991). According to the interpretation criteria proposed by Field (2024), values around .10 indicate a small effect, around .30 a medium effect, and .50 or higher a large effect.
- For O3, possible differences in pedagogical competences and technical knowledge related to the use of GenAI tools according to students' sex were analysed. For this purpose, the Mann-Whitney U test was used, as the assumption of normality was not met.
- For O4 and O5, the relationship between self-perceived academic motivation, self-perceived creativity in designing activities with digital technologies, and competences related to the use of GenAI tools was analysed using Spearman correlation analyses. Both variables were measured using a 10-point Likert scale, where 1 indicated a very low level and 10 a very high level.

All statistical analyses were performed using IBM SPSS Statistics, while the confirmatory factor analysis and the examination of the psychometric properties of the instrument were conducted using SPSS AMOS.

4. ANALYSIS OF THE RESULTS

4.1 Descriptive analysis of students' self-perceived competences in GenAI tools (O1).

Table 3 presents the descriptive statistics for students' self-perceived competences related to the use of GenAI tools before and after the training intervention. In the PCAI-CM dimension, moderate levels were observed in the pretest. The ability of future pedagogues to use academic writing tools to create educational materials showed a relatively higher mean (5.00 ± 1.44), while the use of image generation tools (4.43 ± 1.69) and tools for creating educational videos (3.71 ± 1.47) presented lower values. After the training intervention, posttest scores showed an increase in all the competences evaluated, particularly in the use of academic writing tools (6.14 ± 1.05) and in the creation of audiovisual materials using GenAI tools (5.29 ± 1.42).

In the PCAI-PT dimension, pretest scores indicated moderate levels of self-perceived competence in pedagogical planning with GenAI tools. For example, planning the use of academic writing tools in the teaching process showed a mean of 4.08 ± 1.43 , while planning the use of multimedia presentation tools reached similar values (3.59 ± 1.83). In the posttest, an increase was observed in all the analysed competences, particularly in planning the use of academic writing tools (4.72 ± 1.99) and in adapting GenAI tools to specific areas of knowledge (5.33 ± 1.50).

Finally, the TK-AI dimension showed the lowest initial levels compared to the other dimensions. In the pretest, future pedagogues' knowledge of basic concepts related to AI-GenAI reached a mean of 2.84 ± 1.32 , while knowledge about student data protection (2.65 ± 1.45) and the ability to

solve technical problems related to GenAI tools (2.89 ± 1.34) also showed low values. After the training intervention, a clear increase was observed in all these variables in the posttest, especially in the understanding of basic AI concepts (4.81 ± 1.28) and in the ability to manage issues related to privacy and the responsible use of these technologies (4.65 ± 1.19).

Table 3. Descriptive statistics pretest–posttest.

	Pretest	Posttest
PCAI-CM (Pedagogical competences with AI for Creating Materials)		
As a future pedagogue, I am able to use GenAI academic writing tools (such as ChatGPT, COPILOT, GEMINI) to create teaching materials.	5.00±1.44	6.14±1.05
As a future pedagogue, I am able to use GenAI image-generation tools (such as DALL-E 3, Midjourney, or Microsoft Designer) to create teaching materials.	4.43±1.69	5.01±1.36
As a future pedagogue, I am able to use GenAI video creation and editing tools (such as Synthesia or Heygen) to create teaching materials for my courses.	3.71±1.47	5.29±1.42
PCAI-PT (Pedagogical competences with AI for Planning Tasks)		
As a future pedagogue, I know how to adapt and plan the use of GenAI tools in my subject area.	4.08±1.43	5.33±1.50
As a future pedagogue, I know how to use GenAI tools to plan activities that personalise learning according to different levels and learning styles.	3.27±1.43	4.49±1.84
As a future pedagogue, I am able to plan the use of GenAI academic writing tools (such as ChatGPT) in the teaching and learning process.	3.50±1.73	4.72±1.99
As a future pedagogue, I am able to plan the use of GenAI multimedia presentation tools (such as Canva AI, Gamma) in the teaching and learning process.	3.59±1.83	4.37±2.00

	Pretest	Posttest
TK-AI (Technical Knowledge about AI)		
As a future pedagogue, I understand the basic terms, types, and concepts related to Generative Artificial Intelligence tools.	2.84±1.32	4.81±1.28
As a future pedagogue, I know how to protect students' privacy and data when using GenAI tools with them.	2.65±1.45	4.57±1.44
As a future pedagogue, I know how to solve technical problems that may arise when using GenAI tools in educational contexts.	2.89±1.34	4.65±1.19

Note: Own elaboration. M—mean; SD— standard deviation.

4.2. Differences between pre-test and post-test after the training intervention (O2)

Before analysing differences between pretest and posttest scores, it was examined whether there were initial differences between students from the two academic cohorts included in the study (2024–2025 and 2025–2026). This analysis made it possible to verify whether both cohorts exhibited similar levels of the evaluated competences, thereby strengthening the internal validity of the quasi-experimental design. For this purpose, the mean scores of both cohorts were compared across the three dimensions analysed. The results, presented in Table 4, show that no statistically significant differences were observed between the two academic cohorts in either the pretest or the posttest. These findings indicate that both cohorts had comparable levels of the analysed variables, allowing us to rule out that the differences observed after the intervention were due to pre-existing inequalities between the groups.

Table 4. Baseline equivalence between academic cohorts (2024–2025 and 2025–2026).

Desing	Dimensions	Academic year	M	SD	AC	KC	Kolmogorov-Smirnov			Mann-Whitney		
							KS	gl	p.	U	p.	
Pre-test	PCAI-CM	2024-2025	4.49	1.31	-.92	.28	.205	63	.001	1312.000	.171	
		2025-2026	4.24	1.16	-.47	-.62	.151	49	.007			
	PCAI-PT	2024-2025	3.52	1.53	.67	-.61	.205	63	.001	1398.500	.391	
		2025-2026	3.72	1.43	1.03	-.09	.295	49	.001			
	TK-AI	2024-2025	2.74	1.37	.82	-.34	.203	63	.001	1304.000	.158	
		2025-2026	2.87	0.93	-.39	-.85	.188	49	.001			
	Global	2024-2025	3.58	1.01	.26	-.34	.090	63	.200	1478.500	.703	
		2025-2026	3.61	0.83	.16	-.47	.095	49	.200			
	Post-test	PCAI-CM	2024-2025	5.62	1.02	-.97	.77	.168	63	.001	1235.500	.069
			2025-2026	5.30	1.10	-.31	-.22	.104	49	.200		
PCAI-PT		2024-2025	4.66	1.51	-.29	-.53	.130	63	.010	1455.000	.602	
		2025-2026	4.82	1.63	-.16	-.57	.135	49	.026			
TK-AI		2024-2025	4.80	1.06	-.20	-.63	.160	63	.001	1353.500	.261	
		2025-2026	4.52	1.22	-.14	-.55	.123	49	.062			
Global		2024-2025	5.03	0.91	-.33	-.05	.073	63	.200	1404.500	.415	
		2025-2026	4.88	1.02	-.08	-.78	.098	49	.200			

Note: Own elaboration. M—mean; SD— standard deviation; AC— kurtosis; KC— skewness; KS— Kolmogorov-Smirnov; gl— degrees of freedom; p.—significance.

To examine the changes produced by the training intervention, Wilcoxon signed-rank tests were conducted comparing pretest and posttest scores for each dimension. The results presented in Table 5 show statistically significant differences between pretest and posttest scores in all three dimensions analysed, as well as in the overall score. In the PCAI-CM dimension, statistically significant differences were observed between both measurements according to the Wilcoxon signed-rank test ($Z = -7.398$, $p < .001$). The effect size was large ($r = .70$), calculated using the formula $r = |Z| / \sqrt{N}$, with $N = 112$ valid pairs. Similarly, in the PCAI-PT dimension, statistically significant differences were also identified between pretest and posttest scores ($Z = -5.985$, $p < .001$), with a large effect size ($r = .57$). In the TK-AI dimension, statistically significant differences were again observed between pretest and posttest scores ($Z = -8.490$, $p < .001$), with a very large effect size ($r = .80$). Finally, the overall score also showed statistically significant differences between pretest and posttest measurements ($Z = -8.852$, $p < .001$), with a very large effect size ($r = .84$).

Table 5. Wilcoxon pretest–posttest.

Dimensions		M	SD	CA	KC	Kolmogorov–Smirnov			Wilcoxon	
						KS	gl	p.	Z	p.
PCAI-CM	Pre-test	4.38	1.25	-.71	-.15	.163	112	.000	-7.398	.001
	Post-test	5.48	1.06	-.65	.06	.131	112	.000		
PCAI-PT	Pre-test	3.61	1.49	.77	-.42	.244	112	.000	-5.985	.001
	Post-test	4.73	1.56	-.21	-.55	.091	112	.023		
TK-AI	Pre-test	2.79	1.19	.54	-.28	.114	112	.001	-8.490	.001
	Post-test	4.68	1.14	-.21	-.54	.147	112	.000		
Global	Pre-test	3.59	0.94	.22	-.32	.064	112	.200	-8.852	.001
	Post-test	4.96	0.95	-.22	-.47	.059	112	.200		

Note: Own elaboration. M—mean; SD— standard deviation; CA— kurtosis; KC— skewness; KS— Kolmogorov–Smirnov; gl— degrees of freedom; p.—significance.

4.3. Differences in competences according to students' sex (O3)

To examine whether differences existed by students' sex, Mann–Whitney U tests were conducted for each dimension at both the pretest and posttest stages. The results are presented in Table 6. The findings show that no statistically significant differences were observed between male and female students in any of the analysed dimensions. In the pretest stage, the comparisons conducted using the Mann–Whitney U test did not reveal significant differences in pedagogical competences related to the creation of educational materials with GenAI tools, the planning of tasks using GenAI tools, or in technical knowledge related to GenAI. Similarly, in the posttest stage, no statistically significant differences were identified between both groups.

Table 6. Differences according to sex.

Design	Dimension	Gender	M	SD	AC	KC	Kolmogorov-Smirnov			Mann-Whitney		
							KS	gl	p.	U	p.	
Pre-test	PCAI-CM	Female	4.44	1.15	-.76	.14	.180	81	.000	1130.000	.411	
		Male	4.23	1.48	-.59	-.78	.213	31	.001			
	PCAI-PT	Female	3.46	1.37	.83	.03	.240	81	.000	1062.500	.206	
		Male	4.01	1.72	.51	-1.3	.229	31	.000			
	TK-AI	Female	2.70	1.17	.53	-.14	.095	81	.069	1069.500	.224	
		Male	3.04	1.22	.59	-.60	.159	31	.044			
	Global	Female	3.53	0.88	.35	-.65	.083	81	.200	1054.500	.191	
		Male	3.75	1.05	-.11	.31	.105	31	.200			
	Post-test	PCAI-CM	Female	5.58	0.99	-.65	.35	.132	81	.001	1051.000	.181
			Male	5.23	1.20	-.50	-.54	.159	31	.043		
		PCAI-PT	Female	4.61	1.62	-.21	-.58	.105	81	.028	1084.500	.264
			Male	5.03	1.37	.06	-1.0	.155	31	.057		
TK-AI		Female	4.75	1.06	-.02	-.58	.135	81	.001	1122.000	.381	
		Male	4.48	1.32	-.34	-.92	.168	31	.025			
Global		Female	4.98	0.91	-.13	-.41	.077	81	.200	1241.500	.927	
		Male	4.91	1.09	-.34	-.67	.119	31	.200			

Note: Own elaboration. M—mean; SD— standard deviation; AC— kurtosis; KC— skewness; KS— Kolmogorov-Smirnov; gl— degrees of freedom; p.—significance.

4.4. Relationship between academic motivation, creativity and competences in AI and GenAI (O4-O5)

Spearman correlation analyses were conducted to examine the relationship between academic motivation, self-perceived creativity in designing digital activities, and competences in AI and GenAI. The results are presented in Table 7. Academic motivation did not show statistically significant correlations with any of the analysed dimensions, either in the pre-test or in the posttest. This suggests that students' motivation to continue learning about AI was not clearly related to their self-perceived pedagogical competences or their technical knowledge about AI. In contrast, self-perceived creativity showed several positive and statistically significant correlations with some of the competency dimensions. In the pretest, creativity was positively associated with pedagogical competences for creating materials ($r = .231, p < .05$), pedagogical competences for planning tasks ($r = .439, p < .01$), and the overall competency score ($r = .352, p < .01$). Similarly, in the posttest, creativity continued to show positive correlations with pedagogical competences for creating materials ($r = .235, p < .05$), pedagogical competences for planning tasks ($r = .359, p < .01$), and the overall com-

petency score ($r = .279$, $p < .01$). However, no statistically significant correlations were found between creativity and the technical knowledge about AI dimension ($p > .05$).

Table 7. Correlations between motivation and creativity.

	Before				After			
	PCAI-CM	PCAI-PT	TK-AI	Global	PCAI-CM	PCAI-PT	TK-AI	Global
Motivation	.051	.067	.032	.163	.043	.092	.111	.104
Creativity	.231*	.439**	.052	.352**	.235*	.359**	.040	.279**

Note: Own elaboration. ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

5. DISCUSSIONS

The present study provides quantitative evidence of the impact of a training intervention on the development of pedagogical competences and technical knowledge related to the educational use of GenAI tools among pedagogy students.

In relation to objectives O1 and O2, the results showed that the pedagogy students initially presented moderate levels in the pedagogical competences for the creation of materials with GenAI (PCAI-CM) and the planning of learning activities with GenAI (PCAI-PT), while the technical knowledge about GenAI (TK-AI) was comparatively lower. Following the training intervention, statistically significant improvements were observed in all factors, especially in TK-AI. These results are consistent with previous research showing that training interventions based on GenAI tools promote the development of pedagogical and technological competences in teacher training (Moorhouse et al., 2024; Oh, 2025) and can contribute to improving variables related to professional development, such as teacher self-efficacy (Lu et al., 2024). These findings suggest that participation in practical activities that integrate GenAI tools into educational design tasks helps future educators develop competences to apply these technologies pedagogically in real teaching contexts. This need is especially important because the use of GenAI tools in educational contexts is rapidly increasing. Future professionals must be prepared to integrate these tools critically and responsibly into teaching and learning processes (Rani et al., 2025; Wajeed, 2026). They also need to develop appropriate pedagogical competences and technical knowledge for their educational use (Giannakos et al., 2025; de la Flor Bancalero et al., 2026).

Regarding objective O3, the results of the study did not show statistically significant differences in pedagogical competences or in technical knowledge about GenAI tools according to the sex of future pedagogues. This finding is consistent with some previous studies that also did not find significant differences between male and female students in variables related to AI literacy or the perception of its educational use (Cetin & Celen, 2025). However, other studies have identified differences according to sex, generally showing slightly higher levels among male students in dimensions such as AI literacy, technical knowledge, or confidence in the use of these technologies (Balasa, 2025; Dumagay, 2025; Aksoy et al., 2026; Lee & Zhai, 2024). In this sense, the results of the present study suggest that, at least in this sample, sex is not a determining variable in explaining the development of pedagogical competences and technical knowledge related to the educational use of GenAI. However, these results should be interpreted with caution, as the study is based on a relatively small sample obtained through non-probabilistic sampling and within a quasi-experimental design. Therefore, future research with larger samples and more robust methodological designs is needed to further examine the possible role of sex in the development of competences related to the educational use of GenAI tools, an aspect that will be discussed in greater detail in the following section.

Regarding objective O4, the results showed that academic motivation toward learning about GenAI was not significantly related to pedagogical competences or technical knowledge about GenAI tools. This finding contrasts with previous studies suggesting that hedonic motivation may influence the intention to use AI-based technologies (Venkatesh et al., 2012; De Blanes Sebastián et al., 2022; Acosta-Enriquez et al., 2025). One possible explanation is that many of these studies focus on technology acceptance or intention to use, whereas the present study examines the development of pedagogical competences and technical knowledge through a longitudinal intervention in which future pedagogues developed an educational innovation project using ICT. Therefore, the motivation assessed in this study refers mainly to students' general interest in learning about GenAI tools, which may not necessarily translate into the development of specific pedagogical competences for their use in educational, professional, or socio-community contexts. Further research is needed to explore how different types of motivation toward GenAI tools relate to the development of competences for their educational use.

Finally, regarding objective O5, the results showed that the self-perceived creativity of future pedagogues in designing activities with digital technologies was positively related to several dimensions of pedagogical competences associated with the use of GenAI, especially the PCAI-CM and PCAI-PT factors. However, no significant relationships were found between this variable and the TK-AI factor. This finding is consistent with studies highlighting creativity as a key competence for teachers in the twenty-first century and for the development of innovative educational practices (Newton & Newton, 2014; Cho et al., 2017; Guillén-Gámez et al., 2024). In addition, several studies suggest that AI-supported educational environments can promote creative processes and the design of more innovative learning experiences (Wang et al., 2023), which is particularly relevant for future pedagogues who will need to design and implement innovative educational proposals in educational, professional, and socio-community contexts.

From a theoretical point of view, this study provides empirical evidence on the design of training courses that promote the development of pedagogical competences and technical knowledge related to the educational use of GenAI tools in the initial training of educators, an area still little explored in the scientific literature. From a practical perspective, the results suggest the importance of incorporating training experiences that integrate these technologies into educational design tasks, such as the creation of digital materials or the planning of learning activities. This type of training can be especially relevant for future educators, who could apply these tools in various professional settings. In the educational field, GenAI tools can facilitate the creation of personalized teaching materials, the design of learning activities adapted to different student needs, and the planning of more innovative educational experiences. In the workplace and organizational context, these technologies can support the design of continuing education programs, the development of digital training content, and the creation of interactive materials for generating simulations. Likewise, in the socio-community sphere, GenAI tools can contribute to the design of training initiatives aimed at diverse groups, facilitating the creation of accessible educational materials, the adaptation of content to different cultural or linguistic contexts, the development of digital literacy programs and the promotion of inclusive educational proposals.

6. CONCLUSIONS

This study provides empirical evidence on how a structured university training intervention develops future pedagogues' pedagogical competences and technical knowledge of GenAI tools. Results showed that pedagogy students originally had moderate self-perceived pedagogical competences for developing educational materials (PCAI-CM) and arranging learning activities (PCAI-PT) with GenAI, but lower technical knowledge (TK-AI). After the semester-long intervention in the "ICT as a Support for Educational Innovation" course, all three measures improved statistically, with large impact sizes in technical knowledge. These findings support hypothesis H1 and the study's main goal of assessing pre-service instructors' abilities after project-based GenAI integration. Despite hypothesis H2 and earlier research, sex variations in AI literacy were not significant. Academic motivation was not associated with competency development (rejecting

H3), but self-perceived creativity in designing digital activities was positively associated with pedagogical competences in material creation and task planning before and after the intervention, partially supporting H4. The training improved students' abilities to use GenAI tools such as ChatGPT, Midjourney, Synthesia or HeyGen, among others, for content development, visual design, instructional customisation, and ethics.

Despite the contributions of this study, several limitations should be acknowledged when interpreting the results. First, the sample consisted of 112 pedagogy students from a single university, which limits the generalisation of the findings to other educational programmes and institutional contexts. In this regard, future research should include larger and more diverse samples, involving participants from different universities, geographical contexts, and degree programmes, in order to improve the external validity of the results. Second, the study was based on a single-group quasi-experimental pretest-posttest design. Although this design allows for the analysis of changes after the intervention, it makes it difficult to establish strong causal relationships. Therefore, future studies should consider including control groups or using experimental designs that allow for comparisons between different training approaches.

Third, the study relied on self-report measures focused on students' perceptions of their own competences, which may introduce subjective bias. In this sense, future research could complement these data with performance-based assessments, analysis of student-produced work, or observational techniques that allow for a more objective evaluation of competences. Fourth, the exclusive use of questionnaire-based quantitative data limits a deeper understanding of how these competences are developed and applied in real contexts. Therefore, future studies could adopt mixed-methods approaches that incorporate qualitative techniques such as interviews or focus groups.

Finally, the duration of the intervention was limited to one academic semester, which prevents analysing the development and retention of competences in the medium and long term. Therefore, it would be useful for future research to adopt longitudinal designs that examine the sustainability of the learning achieved. In addition, the study focused exclusively on pedagogy students, which may limit the transferability of the findings to other degree programmes or professional profiles within the educational field. In this regard, it would be advisable to replicate this type of research in other teacher education programmes or across different disciplines in order to analyse possible differences in the development of GenAI competences.

Despite these limitations, the findings of this study highlight the relevance of integrating GenAI training into teacher education programmes. In particular, the results show that participation in practice-oriented learning experiences can support the development of both pedagogical competences and technical knowledge related to the educational use of these tools. From a practical perspective, this suggests the need to incorporate GenAI training as a transversal component across courses, with a focus on ethical use, critical evaluation, and pedagogical application. In addition, teacher educators themselves require ongoing professional development to effectively guide students in this evolving context. As GenAI technologies continue to advance, future pedagogues will need not only technical competences but also the capacity to use these tools in a reflective and pedagogically meaningful way. In this sense, this study represents a step toward understanding how to better prepare future education professionals for the responsible and effective integration of generative AI.

DECLARATION OF COMPETING INTEREST.

The authors have no competing interests to disclose.

AUTHORS' CONTRIBUTION.

Francisco D. Guillén-Gámez contributed to conceptualization, methodology, supervision, project administration, funding acquisition, and writing – review & editing. Akhmad Habibi was responsible for methodology, formal analysis, data curation, and writing. María Belén Morales-Cevallos contributed to investigation, data curation, and writing. Noelia Pelicano-Piris participated in investigation, visualization, and writing, review & editing.

DATA ACCESSIBILITY AND AVAILABILITY STATEMENT.

The content presented in this study is original and can be referenced in the article or supplemental materials. For further information, interested parties are encouraged to contact the corresponding authors.

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REFERENCES

- Acosta-Enriquez, B. G., Villena Zapata, L. I., Huamaní Jordan, O., López Roca, C., Cabrera Cipirán, B. M., Saavedra Villacrez, W., & Arbulu Perez Vargas, C. G. (2025). Acceptance of artificial intelligence as a teaching strategy among university professors: The role of habit, hedonic motivation, and competence for technology integration. *Human Behavior and Emerging Technologies*, 2025(1), 5933157. <https://doi.org/10.1155/hbe2/5933157>
- Aksoy, M., Aksoy, D. A., Polat, E., Hopcan, S., & Bush, A. (2026). Cross-Cultural Patterns in Artificial Intelligence Literacy Development: Investigating Country and Gender Differences Among Pre-Service Teachers in Germany and Türkiye. *European Journal of Education*, 61(1), e70454. <https://doi.org/10.1111/ejed.70454>
- Alieto, E., Abequibel-Encarnacion, B., Estigoy, E., Balasa, K., Eijansantos, A., & Torres-Toukourmidis, A. (2024). Teaching inside a digital classroom: A quantitative analysis of attitude, technological competence and access among teachers across subject disciplines. *Heliyon*, 10(2), 1-15. <https://doi.org/10.1016/j.heliyon.2024.e24282>
- Almazán-López, O., Hasbún, H., & Osuna-Acedo, S. (2025). Generative Artificial Intelligence and (post) digital teacher identity. *International Journal of Educational Research & Innovation (IJERI)*, (24), 1-17. <https://doi.org/10.46661/ijeri.11160>
- Altuna, J., Pascual-Sagastizabal, E., Cruz-Iglesias, E., Aierbe, A., Madinabeitia, A., Marko, I., & Diez-Guiral, U. (2021). Assessing the curriculum and profile of pedagogical professionals for new employment opportunities. *Higher Education Pedagogies*, 6(1), 228-246. <https://doi.org/10.1080/23752696.2021.2007498>
- Balasa, K. A. (2025). Interplay of AI Literacy, Readiness-Confidence, and Acceptance among Pre-Service Teachers in Philippine Higher Education: A Gender, Discipline, and Connectivity Perspective. *EthAlca: Journal of Ethics, AI and Critical Analysis*, (4), 1-14. <https://doi.org/10.56294/ai2025429>
- Baskar, S. (2025). Generative AI: Recent Advances and Their Impact on Education. *Generative AI Approaches to Sustainable Development in Higher Education*, 135-156. <https://doi.org/10.4018/979-8-3693-5623-4.ch006>
- Cetin, O., & Celen, G. (2025). Investigation of Pre-Service Teachers' Artificial Intelligence Literacy and Views on the Use of Artificial Intelligence in Education. *Journal of Education in Science, Environment and Health*, 11(4), 285-304. <https://doi.org/10.55549/jeseh.850>
- Cho, H., Pemberton, C. L., & Ray, B. (2017). An exploration of the existence, value and importance of creativity

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- education. *Current Issues in Education*, 20(1), 1-21.
- Contreras, I., Hossfeld, S., de Boer, K., Wiedler, J. T., & Ghidinelli, M. (2024). Revolutionising faculty development and continuing medical education through AI-generated videos. *Journal of CME*, 13(1), 2434322. <https://doi.org/10.1080/28338073.2024.2434322>
- Daher, R. (2025). Integrating AI literacy into teacher education: a critical perspective paper. *Discover Artificial Intelligence*, 5(1), 1-20. <https://doi.org/10.1007/s44163-025-00475-7>
- de la Flor Bancalero, P., Guillén-Gámez, F. D., Stošić, L., & Giménez-Gualdo, A. M. (2026). Teacher Competencies in the Willingness to Use Artificial Intelligence Pedagogically in the Educational Process: Good Strategies for the Smart Teacher. In *The Role of Smart Education in a Complex World* (pp. 65-92). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-7912-8.ch005>
- de la Flor-Bancalero, P., & Guillen-Gamez, F. D. (2026). What Digital Competencies Should Teachers Possess to Teach Educational Cybersecurity to Students in Schools? Design and Validation of a Teacher Competency Scale. *Technology, Knowledge and Learning*, 1-19. <https://doi.org/10.1007/s10758-026-09954-x>
- Dumagay, A. H. (2025). Preservice teachers and AI in education 5.0: examining literacy, anxiety, and attitudes across gender, socioeconomic status, and training. *EthAlca: Journal of Ethics, AI and Critical Analysis*, (4), 1-15. <https://doi.org/10.56294/ai2025432>
- Field, A. (2024). *Discovering statistics using IBM SPSS statistics*. Sage publications limited.
- Foung, D., Lin, L., & Chen, J. (2024). Reinventing assessments with ChatGPT and other online tools: Opportunities for GenAI-empowered assessment practices. *Computers and Education: Artificial Intelligence*, 6, 100250. <https://doi.org/10.1016/j.caeai.2024.100250>
- Gamlem, S. M., McGrane, J., Brandmo, C., Moltudal, S., Sun, S. Z., & Hopfenbeck, T. N. (2026). Exploring pre-service teachers' attitudes and experiences with generative AI: a mixed methods study in Norwegian teacher education. *Educational Psychology*, 46(1), 27-51. <https://doi.org/10.1080/01443410.2025.2528663>
- García de Blanes Sebastián, M., Sarmiento Guede, J. R., & Antonovica, A. (2022). Application and extension of the UTAUT2 model for determining behavioral intention factors in use of the artificial intelligence virtual assistants. *Frontiers in Psychology*, 13, 993935. <https://doi.org/10.3389/fpsyg.2022.993935>
- Giannakos, M., Azevedo, R., Brusilovsky, P., Cukurova, M., Dimitriadis, Y., Hernandez-Leo, D.,.... & Rienties, B. (2025). The promise and challenges of generative AI in education. *Behaviour & Information Technology*, 44(11), 2518-2544. <https://doi.org/10.1080/0144929X.2024.2394886>
- Guillén-Gámez, F. D., Pinto-Llorente, A. M., Mladenović, M., & Mohamed, A. M. (2026). Design and validation of an instrument to evaluate transformational and managerial leadership in the responsible use of artificial intelligence in educational centers. *RED: Revista de educación a distancia*, 26(83), 1-24. <http://dx.doi.org/10.6018/red.676211>
- Guillén-Gámez, F. D., Ruiz-Palmero, J., & Gómez-García, M. (2024). Digital competences in research: creativity and entrepreneurship as essential predictors for teacher training. *Journal of Computers in Education*, 11(4), 1263-1282. <https://doi.org/10.1007/s40692-023-00299-3>
- Guillén-Gámez, F. D., Sánchez-Vega, E., Colomo-Magaña, E., & Sánchez-Rivas, E. (2025). Incident factors in the use of ChatGPT and dishonest practices as a system of academic plagiarism: the creation of a PLS-SEM model. *Research & Practice in Technology Enhanced Learning*, 20, 1-24. <https://doi.org/10.58459/rptel.2025.20028>
- Hashim, S., Omar, M. K., Ab Jalil, H., & Sharef, N. M. (2022). Trends on technologies and artificial intelligence in education for personalized learning: systematic literature. *Journal of Academic Research in Progressive Education and Development*, 12(1), 884-903. <http://dx.doi.org/10.6007/IJARPED/v11-ii/12230>
- Heine, S., & König, J. (2025). Applying artificial intelligence in teacher education: Preservice teachers' attitudes and reflections in using ChatGPT for teaching and learning. *European Journal of Teacher Education*, 48(5), 934-963. <https://doi.org/10.1080/02619768.2025.2540791>
- Heng, C. K., Sathasivam, R. V., Mafarja, N., & Rahim, S. S. A. (2026). Exploring the benefits and challenges of AI-driven lesson planning among preservice science teachers. *STEM Education*, 6(1), 1-20. <https://doi.org/10.3934/steme.2026001>
- Huang, T., Wu, C., & Wu, M. (2025). Developing pre-service language teachers' GenAI literacy: an interventional study in an English language teacher education course. *Discover Artificial Intelligence*,

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5(1), 163. <https://doi.org/10.1007/s44163-025-00435-1>

- Hung, W., & Sitthiworachart, J. (2020). In-Service Teachers' Conception of Creativity and Its Relation with Technology: A Perspective from Thailand. *The Asia-Pacific Education Researcher*, 29(2), 137-146. <https://doi.org/10.1007/s40299-019-00460-6>
- Karaduman, C. (2025). Pre-service EFL teachers' perceived AI literacy and competency: The integration of ChatGPT into English language teacher education. *SAGE Open*, 15(3), 1-16. <https://doi.org/10.1177/21582440251379712>
- Krishnan, R. B., Subramaniaswamy, V., Rajasekar, E., & Manikandan, G. (2025). Impact of Commercial Applications on GenAI with Its Evolving Landscape. In *Generative AI and Creativity* (pp. 243-261). Auerbach Publications. <https://doi.org/10.1201/9781003533009-16>
- Lu, J., Zheng, R., Gong, Z., & Xu, H. (2024). Supporting teachers' professional development with generative AI: The effects on higher order thinking and self-efficacy. *IEEE transactions on learning technologies*, 17, 1267-1277. <https://doi.org/10.1109/TLT.2024.3369690>
- Memon, T. D., & Kwan, P. (2025). A Collaborative Model for Integrating Teacher and GenAI into Future Education. *TechTrends*, 69(6), 1-15. <https://doi.org/10.1007/s11528-025-01105-w>
- Meylani, R. (2024). Artificial intelligence in the education of teachers: A qualitative synthesis of the cutting-edge research literature. *Journal of Computer and Education Research*, 12(24), 600-637. <https://doi.org/10.18009/jcer.1477709>
- Mohamed, A. M., Shaaban, T. S., Bakry, S. H., Guillén-Gámez, F. D., & Strzelecki, A. (2025). Empowering the faculty of education students: Applying AI's potential for motivating and enhancing learning. *Innovative Higher Education*, 50(2), 587-609. <https://doi.org/10.1007/s10755-024-09747-z>
- Moorhouse, B. L., Wan, Y., Wu, C., Kohnke, L., Ho, T. Y., & Kwong, T. (2024). Developing language teachers' professional generative AI competence: An intervention study in an initial language teacher education course. *System*, 125, 103399. <https://doi.org/10.1016/j.system.2024.103399>
- Moral-Sánchez, S. N., Ruiz-Rey, F. J., & Cebrián-de-la-Serna, M. (2023). Análisis de chatbots de inteligencia artificial y satisfacción en el aprendizaje en educación matemática. *International Journal of Educational Research and Innovation (IJERI)*, (20), 1-14. <https://doi.org/10.46661/ijeri.8196>
- Newton, L. D., & Newton, D. P. (2014). Creativity in 21st-century education. *Prospects*, 44(4), 575-589. <https://doi.org/10.1007/s11125-014-9322-1>
- Oh, S. (2025). Education classes for pre-service teachers using text-video-based ai. *Journal of Baltic Science Education*, 24(3), 538-551. <https://dx.doi.org/10.33225/jbse/25.24.538>
- Öncü, S., Guillén-Gámez, F. D., & Çiğdem, H. (2026). Redefining Participation: A Generative Approach to Elevating Student Engagement in Blended Learning Spaces. In *Generative AI in Education: Theories, Applications, and Ethical Frontiers* (pp. 93-119). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-95-4871-2_6
- Radiowala, A. A. (2024). A study of usage of AI tools and their impact on quality and efficiency of content development. *Journal of Global Communication*, 17(2), 102-111. <http://dx.doi.org/10.5958/0976-2442.2024.00015.9>
- Rani, J., Guru, R., Santhanam, S., Molla, W. T., Singh, J., & Dutt, S. (2025). AI Revolutionizing Education: Exploring Trends, Technologies, and Ethical Considerations for Future Learning Environments. *Implementing AI Tools for Language Teaching and Learning*, 1-24. <http://doi.org/10.4018/979-8-3693-7260-9.ch001>
- Rehmat, M. A., Hassan, H., Khan, H. A., & Abrar, K. (2025). Artificial Intelligence in the Classroom: Teachers' Lived Experiences and Ethical Concerns in Educational Integration. *ASSAJ*, 4(02), 629-645.
- Rosenthal, R. (1991). Effect sizes: Pearson's correlation, its display via the BESD, and alternative indices. <https://doi.org/10.1037/0003-066X.46.10.1086>
- Romero-Martínez, S. J., Guillén-Gámez, F. D., Ordóñez-Camacho, X. G., & Mayorga-Fernández, M. J. (2020). Desarrollo y estructura factorial de un instrumento de actitud hacia el uso de la tecnología para la enseñanza y la investigación en docentes universitarios. *Revista de Tecnología, Ciencia y Educación*, (16), 85-111. <https://doi.org/10.51302/tce.2020.443>
- Salifu, I., Arthur, F., Arkorful, V., Abam Nortey, S., & Solomon Osei-Yaw, R. (2024). Economics students' behavioural

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- intention and usage of ChatGPT in higher education: A hybrid structural equation modelling-artificial neural network approach. *Cogent Social Sciences*, 10(1), 2300177. <https://doi.org/10.1080/23311886.2023.2300177>
- Singh, R. J. (2023). Transforming higher education: The power of artificial intelligence. *International Journal of Multidisciplinary Research in Arts, Science and Technology*, 1(3), 13-18.
- Stöhr, C., Ou, A. W., & Malmström, H. (2024). Perceptions and usage of AI chatbots among students in higher education across genders, academic levels and fields of study. *Computers and Education: Artificial Intelligence*, 7, 100259. <https://doi.org/10.1016/j.caeai.2024.100259>
- Szmyd, K., & Mitera, E. (2024). The impact of artificial intelligence on the development of critical thinking skills in students. *European Research Studies Journal*, 27(2), 1022-1039. <https://doi.org/10.35808/ersj/3876>
- Tunjera, N., & Chigona, A. (2025, October). *AI Literacy in Preservice Teachers Preparation Programs: A Global Meta-Analysis*. In European Conference on e-Learning (pp. 363-370). Academic Conferences International Limited. <https://doi.org/10.34190/ecel.24.1.4174>
- Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the Unified Theory of Acceptance and Use of Technology1. *MIS quarterly*, 36(1), 157-178. <https://doi.org/10.2307/41410412>
- Wajeed, M. A. (2026). Revolutionizing Higher education with generative AI: prospects, challenges, and future directions. In *Generators, bots, and tutors: creative approaches to human-AI synergy in classroom instruction* (pp. 131-160). IGI Global Scientific Publishing. <http://.doi.org/10.4018/979-8-3373-0847-0.ch005>
- Wang, S., Sun, Z., & Chen, Y. (2023). Effects of higher education institutes' artificial intelligence capability on students' self-efficacy, creativity and learning performance. *Education and Information Technologies*, 28(5), 4919-4939. <https://doi.org/10.1007/s10639-022-11338-4>
- Zayas, J. D. M., & Rofi'ah, N. (2022). The effect of digital literacy skills on improving teacher creativity. *INSECTA: Integrative Science Education and Teaching Activity Journal*, 3(2), 168-174. <https://doi.org/10.21154/insecta.v3i2.5100>