Chapter 7 / Capítulo 7

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Generative artificial intelligence and design thinking as a transformational learning strategy in initial teacher training

Inteligencia artificial generativa y design thinking como estrategia de aprendizaje transformacional en la formación docente inicial

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ABSTRACT

The study analyzes the perceived change in knowledge, skill, and pedagogical appropriation regarding the use of generative artificial intelligence for the development of low-fidelity prototypes with a Design Thinking approach in the Emerging Technologies and Their Applications course aimed at distance learning Early Childhood Education students at a private Peruvian university. It is a mixed descriptive-exploratory single-case design with a post-then-pre retrospective approach, applied to 15 students through voluntary sampling. The instrument designed combined pre-post Likert scales, an analytical rubric that assesses the quality of the prototypes, and open-ended questions for metacognitive reflection. The results show a significant improvement in knowledge about GAI, with significant differences between before and after the training experience. Qualitative evidence confirms transformational learning in the transition from instrumental use to conscious and creative use of this technology; learning to use AI moves from an instrument "as a search engine" to a tool for the production of educational resources. It is concluded that the integration of AI with Design Thinking favors the pedagogical-ethical appropriation of technology in initial teacher training and educational innovation.

Keywords: Generative Artificial Intelligence; Design Thinking; Prompteo; Pedagogical Appropriation; Transformational Learning.

RESUMEN

El estudio analiza el cambio percibido en el conocimiento, habilidad y apropiación pedagógica sobre el uso de la inteligencia artificial generativa para la elaboración de prototipos de baja fidelidad con enfoque Design Thinking en el curso de Tecnologías Emergentes y sus Aplicaciones dirigido a estudiantes de Educación Inicial de modalidad a distancia en una universidad privada peruana. Se trata de un diseño descriptivo-exploratorio mixto de caso único, con enfoque post-then-pre retrospectivo, aplicado a 15 estudiantes mediante muestreo voluntario. El instrumento diseñado combinó escalas Likert antes-después, una rúbrica analítica que valora la calidad de los prototipos y preguntas abiertas de reflexión metacognitiva. Los resultados muestran una mejora significativa en el conocimiento sobre IAG, con diferencias significativas entre el antes y el después de la experiencia formativa. Las evidencias cualitativas confirman el aprendizaje transformacional en la transición de uso instrumental a uso consciente y creativo de esta tecnología; el aprendizaje del uso de la IA pasa de instrumento "como buscador" a una herramienta para la producción de recursos educativos. Se concluye que la integración de la IAG con Design Thinking favorece la apropiación pedagógica-ética de la tecnología en la formación docente inicial y la innovación educativa.

Palabras clave: Inteligencia Artificial Generativa; Design Thinking; Prompteo; Apropiación

Pedagógica; Aprendizaje Transformacional.

INTRODUCTION

The expansion of generative artificial intelligence (GAI) has transformed university education, teacher training, and professional development worldwide. UNESCO (2023) and the OECD (2023) have stated that GAI enables more personalized and effective teaching and encourages creativity, but also that it needs to be regulated through ethical frameworks and the development of teaching skills to monitor and prevent bias and irresponsible use of these tools. Similarly, the World Bank (2024) notes that educational transformation policies focus on the crucial role of teacher competence in digital literacy and warns of multiple skills gaps that narrow the scope of these technological tools. Along the same lines, the IDB (2025) warns that AI's potential, like that of any other technology, depends on contextualization and teaching skills. A recent study by ECLAC (2024) shows that the pedagogical integration of emerging technologies in the region has lagged, despite the expansion of internet coverage, which is inconsistent with the quality of service. Furthermore, IESALC-UNESCO (2025) warns about the rapid incorporation of AI in higher education without clear national and institutional education policies or competency frameworks, which creates ethical and quality risks in the training of professionals.

In Peru, the process of institutionalizing AI is advancing through a series of recent regulations. Supreme Decree No. 115-2025-PCM establishes the national policy on artificial intelligence, prioritizing its ethical application in education and public administration (PCM, 2025). Law No. 31814 and its regulations promote AI research and development in the country, bringing together the academic, public, and private sectors (Congress of the Republic, 2025; MetaRed Peru, 2024). In the context of university higher education, SUNEDU consolidated the permanence of distance learning through RCD No. 0040-2024-SUNEDU-CD, which requires innovative strategies to ensure quality in virtual environments (SUNEDU, 2024). Within this framework, the following research question arises: To what extent did the perceived level of knowledge, skill, and pedagogical appropriation of the use of generative artificial intelligence change in distance learning early childhood education students after participating in the creation of low-fidelity prototypes using Design Thinking in the subject of Emerging Technologies and their Applications?

The proposed general objective was to analyze the perceived change in knowledge, skills, and pedagogical appropriation of the use of generative artificial intelligence in the process of creating low-fidelity prototypes with Design Thinking in the course " Emerging Technologies and Their Applications) among distance learning early childhood education students at a private Peruvian university. The specific objectives were to: i) analyze the change perceived by students before and after regarding knowledge about GAI, understanding, and development of prompts,

Moreover, pedagogical use of AI ii) to characterize the pattern of AI use throughout the phases of Design Thinking (empathize, define, ideate, prototype, test) and determine in which phases students report the greatest usefulness iii) describe metacognitive reflections on what changed in their way of prompting, perception of ethics and critical judgment on the responsible use of AI and its transfer to future teaching practice in Early Childhood Education.

Although at first glance, it would seem evident that the application of active Design Thinking methodologies and the guided use of IAG could result in some degree of improvement in learning, the value of this study lies not in demonstrating a noticeable change, but rather in understanding the nature, quality, and significance of that change in a real educational context. The scientific relevance of the work lies in the analysis of how early childhood education students reconstruct

their understanding and pedagogical practice in distance learning conditions and with limited technological resources when they interact with IAG from a perspective of creativity, ethics, and reflection, observing an epistemological change in their understanding of technologies and in their perception and professional identity as teachers in training.

It is essential to note that the aim is not to examine technical or instrumental progress, but to present an initial approach to the transformational learning that emerges when students, future early childhood teachers, stop considering IAG as a search engine, a kind of expanded Google, and recognize it as a tool for designing and co-creating educational resources, which, regulated according to the needs and purposes of "human intelligence," gives rise to a "hybrid" work methodology.

Methodologically, this research provides a replicable model of pedagogical integration of IAG, articulated with the Design Thinking approach and evaluated through a post-then-pre design plus a prototype evaluation rubric. This combination enables the rigorous study of technological appropriation processes in scenarios where there are no prior baselines, but somewhat perceptible, reflective transformations. Finally, by offering evidence situated in the context of initial teacher training in distance learning, it contributes to the field of educational innovation by reinforcing the role of creativity, pedagogical mediation, and equity in digital access as essential conditions for democratizing the responsible use of artificial intelligence in education.

In recent years, a significant body of empirical evidence has been generated on the integration of generative AI into design thinking, project-based learning, and teacher training, which will be reviewed below. In a 12-week course with 112 undergraduate students, Rana et al. (2025) introduced generative AI into the five phases of design thinking and analyzed students' reflections using a mixed-methods approach. They found four main themes: perceived benefits, such as increased creativity and accessibility; ethical concerns, such as bias and authorship; the transition from initial mistrust to strategic adoption; and epistemic vigilance to validate AI responses critically. Although 86 % of responses were positive in tone, responses to ethical issues elicited strong negative sentiment. Similarly, in a 2015–2022 longitudinal quasi-experimental study with three cohorts of a design thinking course (control group without AI during 2015–2022, first experimental group with exploratory use of ChatGPT/DALL·E, and a second experimental group with guided and structured AI integration), Martínez (2025) found that teams with generative AI produced more ideas that were better rated for originality and creativity. They also produced prototypes that were better rated by rubrics and expert feedback. Specifically, in the group that received better structuring, the average prototype quality increased from 2,72 to 5,00 on a scale of 1 to 5, without substantially increasing the time spent on prototyping. At the same time, the author documents a significant reduction in cooperation in the ideation phase when AI is used without framing—cooperation that, however, is recovered under protocols for collaborative AI use and parallel reflection. Also, in a higher education workshop focused on innovation, Fischer et al. (2025) analyzed the use of ChatGPT as a "design companion" throughout the design thinking process. The results show that ChatGPT particularly supported the expansion of ideas and the synthesis of user information, but tended to produce generic solutions when specific prompts were not designed and combined with team discussions. The study concludes that prototype quality improves when AI is used to enrich alternatives, which the team then filters and adapts, rather than accepting AI proposals uncritically.

Regarding the application of project-based learning (PBL) including IAG, the work of Yi

et al (2025) was found, who in one year and with 21 groups of university students from the Faculty of Education in Macao designed an online PBL platform with an IAG plug-in and analyzed behavior sequences using Lagged Sequential Analysis. The study showed patterns of use in which students ask iterative questions to the AI, reinterpret the answers, and adjust them to the project requirements, which is interpreted as supporting deep learning and critical thinking. When segmenting students into high- and low-performing groups, a relatively straightforward pattern emerged: those who performed better developed a "deep" use of AI, with more precise questions, more effective keywords, significantly longer and more innovative dialogues, and even "disrespectful" questions. This pattern correlated with quality and innovation in the projects. The low-performing groups had significant difficulty "converging" on problems, with less interaction over time and more reliance on superficial responses. Meanwhile, the longitudinal data sequence shows an important negative aspect: over time, some students tend to rely too much on AI and reduce their own creative behavior. This poses risks to critical thinking and self-determination if there are no explicit pedagogical interventions.

In the context of teacher training, particularly at the early childhood education level, recent evidence has focused on the competencies, attitudes, and needs of future teachers regarding AI. Kolhatin's (2025) narrative review of AI in teacher training summarizes empirical studies published between 2022 and 2025 on the topic, finding that the trends addressed included the development of AI literacy, the impact on pedagogical content knowledge, and the relevance of ethical issues. This author concluded that although generative AI can improve teacher and student performance through material design, feedback, and personalization, important issues remain, including premature ethical frameworks, resistance to change, and limited systematic development in initial training. On the other hand, in relation to Education 5.0, a quantitative study by Hiedie (2025) with 378 future teachers examined AI literacy, anxiety, and attitudes. Teachers who were previously literate in AI had a significantly higher level than those who were literate in AI but had no prior training. However, this did not result in a significant anxiety reduction. In addition, a strong negative correlation was found between literacy and anxiety, and relationships between higher literacy and less fearful or ambiguous attitudes toward AI.

Furthermore, within this framework, a qualitative study by Kölemen and Yıldırım (2025) with preschool teachers identified three main areas of opinion: awareness of opportunities to develop cognitive and flexibility skills in children; perception of the "double-sided" nature of AI, with concerns about developmental risks, loss of human interaction, and overexposure to screens; and shortcomings in infrastructure, institutional support, and teacher competencies as critical barriers. Teachers explicitly point to the need for specific training, teaching guides, and materials adapted to early childhood in order to integrate AI safely and meaningfully.

Generative artificial intelligence (GAI) in education is defined as systems that generate personalized educational materials, such as texts, exercises, assessments, simulations, and multimedia resources, tailored to students' needs and learning styles (Farrelly & Baker, 2023; Ruiz-Rojas et al., 2023; Mittal et al., 2024; Bahroun et al., 2023). It is based on machine learning models, huge language models (LLMs) such as ChatGPT, and neural networks that analyze large volumes of data to produce coherent and relevant responses, explanations, or educational materials, simulating human production (Lodge et al., 2023; Janumpally et al., 2025; Bahroun et al., 2023). It is a resource that complements teaching, where educators design, supervise, and adapt AI-generated materials to ensure their pedagogical and ethical relevance (Giannakos et al., 2024; Farrelly & Baker, 2023; Samala et al., 2024).

In this vein, the IDB emphasizes that for GAI to revolutionize education, universities must

promote teachers' mediating role and prepare students to use technology critically. Dialogue with a GAI model depends on the quality of the prompt, or the textual input that guides its responses. This process, called "," requires clarity, context, purpose, and structure (Gordon, 2024). From an educational perspective, formulating prompts is a metacognitive pedagogical skill, as it requires planning, anticipation, and evaluation of the GAI's responses in relation to educational goals or purposes.

Various empirical studies confirm that well-designed *prompts* promote more accurate interactions, meaningful learning, and the development of critical thinking (Mastery et al., 2025). *Prompt* design is not a minor technical skill: it involves understanding the logic of AI, taking an active role, and reflecting on the educational value of the output generated. In this vein, UNESCO (2023) recommends promoting AI literacy so that students and teachers learn to formulate instructions with ethical criteria and educational purpose, avoiding both uncritical automation and algorithmic plagiarism.

Design Thinking (DT) is conceived as a methodology for the creative process and human-centered problem-solving. It consists of five stages (empathize, define, ideate, prototype, and test) and promotes iteration, collaboration, and deep understanding of the user (Brown, 2008; Razzouk & Shute, 2012). In education, design thinking has established itself as an active methodology that enhances creativity, self-efficacy, and the ability to apply knowledge to real-world contexts. According to the MIT Teaching + Learning Lab (2024), AI can help generate ideas, simulate solutions, and create prototypes quickly in an enabling environment where students know how to control and evaluate the model's responses; such a relationship requires a balance between human creativity and artificial intelligence, with the teacher acting as a critical mediator. In teacher training, the combination of DT and IAG not only improves technical skills but also encourages transformational learning: awareness of how to do DT, critical reflection on the ethics of these products, and their adaptation to children. Therefore, DT provides a procedural framework, and IAG provides creative potential; together, they form an ecosystem whose potential must be documented through research.

DEVELOPMENT

Materials and methods

The study used a retrospective post-then-pre design (perceived before/after comparison at a single point in time after the experience), along with a qualitative component that prompted evidence and metacognitive reflection. This design has proven to be a valid alternative when there is no prior baseline and when the intervention modifies the understanding of the construct being evaluated, which complicates accurate self-assessment at the outset. The post-then-pre approach reduces response bias that occurs when participants, at the beginning of the process, overestimate their knowledge or skills due to a limited understanding of the subject. By measuring both perceptions at a single point in time after the intervention, participants can use a similar conceptual and experiential frame of reference to assess their actual change (Pratt et al., 2000; Banghi et al., 2012).

The target population consisted of students enrolled in one of the classes for the course Emerging Technologies and Their Applications in Early Childhood Education, a distance-learning program at a private Peruvian university, taught by the author of this research during block A of the 2025, 2 semester. Although 25 students were enrolled in the class, the final sample consisted of 15 students who voluntarily agreed to participate, developed the course project with the support of IAG, completed the questionnaire, and provided evidence.

A non-probabilistic convenience and voluntary sampling was used, typical of descriptive-exploratory classroom studies. The questionnaire collected information on prompting, perceived usefulness, knowledge, forms of use, and attitudes about IAG. It was distributed through the virtual classroom, videoconference, and WhatsApp, along with the informed consent form. The application was cross-sectional and conducted at the end of the prototyping activities, in the last week of the course. The analytical rubric was applied to the students' prototypes as authentic evidence of learning. This gives the study ecological validity, thanks to the contrast between what was perceived and what was produced; this allows us to know the degree of knowledge transfer and pedagogical appropriation of generative AI in the creation of educational solutions through Design Thinking.

RESULTS

The findings presented allow us to describe and analyze the results obtained during the study with respect to the objectives set. First, the self-perceived changes in students' knowledge, skills, and pedagogical appropriation of generative artificial intelligence are presented. Second, descriptive and inferential analyses are established based on the review of the products of the Design Thinking process, to provide a holistic perspective on the learning achieved.

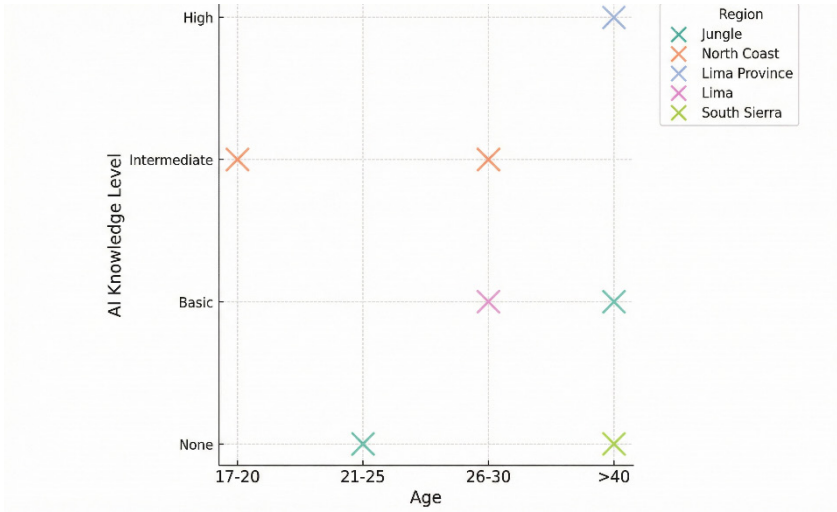

Figure 7.1. Students by age, region, and self-reported level of AI knowledge at the beginning of the course

The bubble chart shown in figure 7.1 provides a strong visual contrast of the age, geographic diversity, and level of knowledge about AI use among participants at the beginning of the course. The most extraordinary diversity is evident in the over-40 age group, which makes up 42,8 % of the total sample and shows knowledge levels about AI distributed across three regions (the provinces of Lima, Selva, and Sierra Sur). The 26–30 age group represents 28,6 % and shows basic and intermediate levels concentrated in urban areas (Lima and Costa Norte). The youngest groups, under 25 years of age, show no or intermediate levels and come from Selva and Costa Norte.

Together, the graph confirms that, at the start of the course, there was a heterogeneous distribution of AI knowledge, mostly at initial levels (none, basic, and intermediate), which confirms the openness to the adopted training approach —based on Design Thinking and reflective prompting—as a means of leveling and enhancing digital skills in initial teacher training.

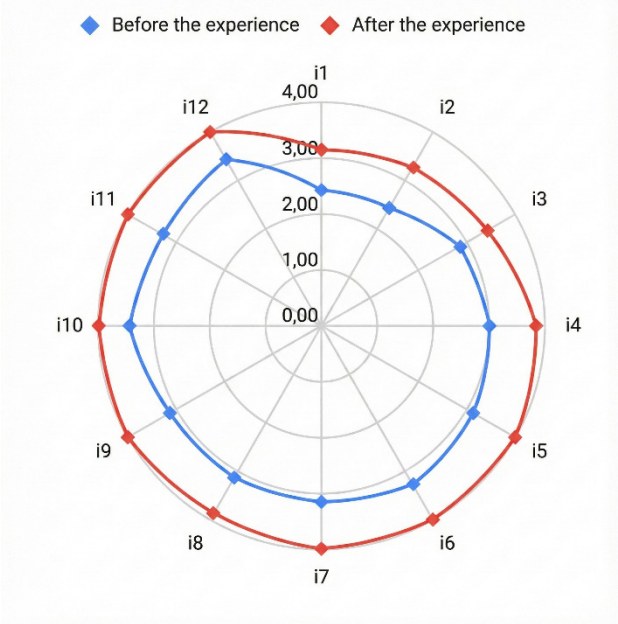

Figure 7.2 Assessment of the level of knowledge and skills in AI before and after taking the course Emerging Technologies and their Applications

Figure 7.2 shows a comparative evolution in the level of knowledge and skills regarding generative artificial intelligence (GAI) reported by students before and after participating in the Emerging Technologies course.

There is an increase in all items evaluated. The blue line represents the values before the experience, with scores ranging from 2,0 to 2,5. In contrast, the red line after the experience approaches or exceeds level 3,5 in most items. The items with the most significant increase are located on the axis corresponding to the dimensions of understanding the role of AI in teaching, the ability to develop effective prompts, and the pedagogical use of AI for the creation of educational materials, denoting increases in applied and creative skills.

Table 7.1. Assessment of the level of knowledge and skills on AI before and after taking the course Emerging Technologies and their Applications

Wilcoxon W	Statistic	p	Means	Biseriated rank correlation
Knowledge and skills prior to the course	78,00	0,002	3,14	Effect size 1,00
Knowledge and skills after the course			3,93	

The nonparametric analysis using the Wilcoxon signed-rank test, shown in Table 1, identified statistically significant differences between pre- and post-course measurements in knowledge and skills related to IAG (W = 78,00, p = 0,002); these results indicate differences between the pre- and post-course scores reported by the students. The mean before the course was 3,14 and after the course 3,93, indicating a significant increase. In addition, the effect size, estimated using the biserial correlation of ranks (r = 1,00), indicates a significant effect, suggesting that the promotion experience had a very significant impact, according to the reports. From an educational perspective, this confirms that generative AI and the Design Thinking approach in Emerging Technology have fostered transformative learning.

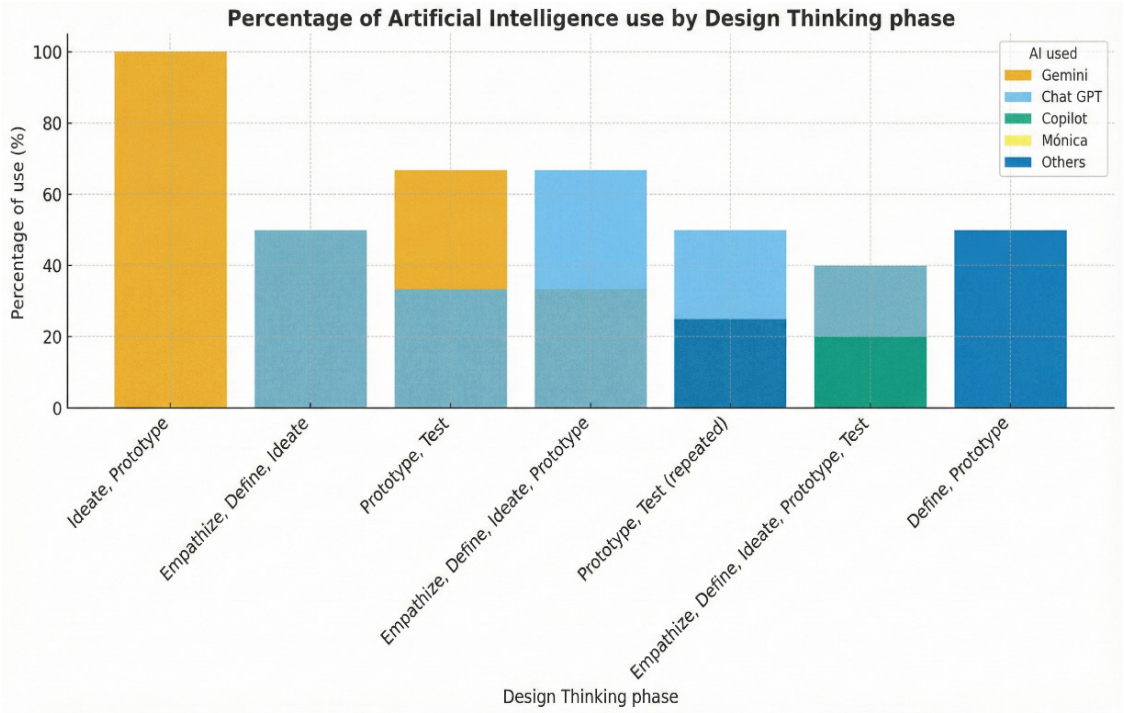

Figure 7.3.GAGs used by students in each of the Design Thinking phases

Figure 7.3 shows the percentage distribution of the use of different Generative Artificial Intelligences (GAIs)—Gemini, ChatGPT, Copilot, Monica, and others—in the different phases of Design Thinking. It can be seen that ChatGPT and Gemini account for the highest usage in all phases, far exceeding the other tools. ChatGPT has its highest percentages (around 30 % of the total in each phase) in the empathize, define, ideate, prototype, and test stages, highlighting its cross-cutting roles in cognitive mediation, ideation, and prototype evaluation. Its versatility in generating ideas, writing texts, and providing feedback on processes positions it as the most widely used AI throughout the innovation cycle.

Gemini also registers significant percentages (around 25 %–30 %), especially in the empathize, ideate, and prototype phases, suggesting that it was used as creative support and for information search during the conceptualization of solutions.

In contrast, Copilot, Monica, and other AIs reach only marginal percentages (below 10 % in most phases), indicating sporadic and complementary use, likely linked to specific technical support or design tasks.

Table 7.2 presents students' progressive metacognitive reflections on their interactions with AI. Overall, the responses move from a superficial knowledge of AI to a conscious, self-regulated, and strategic understanding of prompting for the co-creation process, recognizing that obtaining functional responses depends on the accuracy of the instructions. Then, recognition of the effort required emerges, reflecting a realistic perception of learning prompting as a skill that demands practice and self-reflection. Likewise, the category of assessing clarity and order shows that IAG is increasingly seen not only as a generator of texts but also as a form of cognitive scaffolding that facilitates the organization of one's own ideas. Finally, inspiration and modeling

underscore the value of observational learning: students learn to refine their strategies by observing compelling examples, especially those demonstrated by the teacher.

Table 7.2. Metacognitive reflections on what changed in their way of prompting categories of change in prompting practice

Category	Description	Illustrative quotes
Moving from the general to the specific	IAG is not just for "summary information," but a tool that requires precision in instructions to obtain useful results and avoid errors.	*"...at first I thought that IAG was only used to obtain summary information, but during the course I realized that this is not the case, and I am very happy to have learned how to use it." / "...at the beginning, how to give instructions to get the right answer." / "...some of the mistakes that the AI made must have been because I didn't tell it exactly what I wanted..."*
Recognition of the effort required	The student realizes that prompting correctly is a skill that involves initial difficulty and requires constant practice.	*"...At first, I had a hard time because I didn't know anything about AI, Gimini, or ChatGPT, but with practice, I improved." / "...I didn't understand how to use it, and its functions are very complicated for me..." / "...At first, I had difficulty formulating clear prompts and getting accurate answers, but with practice I improved." / "... actually, I find it a little difficult to make prompts..."*
Assessment of clarity and order	The use of AI is perceived as a way to organize and clarify one's own ideas, beyond the mere generation of content.	*"...AI can help us clarify our ideas..." / "...since it captured my ideas in a draft and AI organizes me better, I don't copy and paste what AI does..."*
Inspiration and modeling	Observing effective *prompts* (such as those from the teacher) serves as a model for improving one's own technique.	*"...I was surprised by the prompt the teacher made in the prototyping. I did a test before, but it didn't turn out as well as that prompt..."*

Table 7.3. Ethical awareness, critical judgment, and transfer to teaching practice

Category	Description	Illustrative quotes
Verification and quotes		*"I was surprised because I saw that AI can be used to do many feasible things and come up with more organized and concrete ideas, as well as not relying on citations or references."/ "Don't rely on citations, references, or links provided by AI." / "I have already seen it make mistakes, and I see some works that are similar." / "I suggest promoting critical thinking, checking the accuracy, reviewing, and improving the content."*
Avoid dependence and plagiarism		*"AI does not cover for you or allow you to substitute good research work."/ "I think AI can be used as a support, but we cannot substitute it for personal thinking. We must also check its accuracy..." / "Don't depend on it, but think critically, otherwise we will live enslaved by AI dependency."*
Ethical and professional application	Integrate critical judgment into its use, citing and ensuring that the tool is a complement, not a replacement.	*"I would apply ethics and integrity by using GAI responsibly, citing sources, avoiding plagiarism, and using the tool only as a support for my own thinking." / "Applying honesty and professional ethics, transparency, and responsibility for the work done."*

Table 7.3 shows significant progress toward ethical and critical awareness in the use of generative artificial intelligence (GAI), demonstrating that students not only learned to use the tool but also to reflect on its moral and professional implications. The first quote explicitly recognizes the need to verify the information generated by AI and not to trust the references it provides blindly. This self-awareness represents a key step toward critical digital literacy, as students learn to validate sources and take responsibility for the accuracy of content.

Another student mentioned that dependence and plagiarism must be avoided, demonstrating a deeper understanding of AI as complementary support rather than a substitute for personal thinking or intellectual effort. Finally, the ethical and professional application category summarizes the attitudinal shift toward the responsible, honest, and transparent use of AI in academic and teaching contexts. Students express a clear intention to apply the principles of integrity, proper citation, and balanced use of technology, demonstrating the transfer of ethical learning to their future professional practice.

Table 7.4 reflects how students project the use of IAG beyond the course, integrating it as a pedagogical, training, and personalized support resource within their teaching role. The first category, generation of materials and activities, shows a practical orientation towards the creation of personalized teaching and visual resources, suggesting a technological appropriation focused on improving the learning experience.

Table 7.4. Transfer to future teaching practice in early childhood education

Category	Description	Illustrative quotes
Generation of materials and activities	Use IAG to create adapted visual or teaching resources.	*"I can generate personalized images..." / "I plan to incorporate IAG as a support for creating teaching materials, designing interactive activities..."*
Support for self-training and planning	Use it as a resource to stay up to date or find inspiration for your own ideas.	*"Looking for information to improve my own ideas." / "Up-to-date advice and suggestions on educational teaching." / "I want it to be like my guide, my virtual teacher who gives me advice but doesn't do it for me."*
Personalization and support	Apply IAG to adapt the teaching-learning process to the specific needs of children.	*"Offering personalized support to students." / "Personalizing my students' learning..."*

In the second category, support for self-training and planning, we see a reflective use of the tool as a source of continuous updating, consultation, and guidance for pedagogical planning, understanding AI not as a substitute but as a training companion, reinforcing its role in lifelong learning and professional self-training. Finally, the category of personalization and support demonstrates an advanced understanding of IAG's potential to differentiate teaching and offer individualized follow-up, adjusting strategies to each child's characteristics and pace.

The overall analysis reveals a significant change among students: i) from a simplistic view to the sophistication of using AI. There was a shift from viewing IAG as a simple practice of summarizing or searching for information to one that requires precision, effort, and critical thinking. ii) Strong emphasis on ethical critical judgment: the students demonstrate a highly defined ethical stance, focused on academic integrity: "do not be overconfident," "do not copy and paste." That is, they project IAG as a "support" and not as a "substitute" for human thought, a critical ethical judgment for future professional practice. iii) Teaching projection with IAG as a creative and personalized ally; students report that these tools encourage creativity in the development of teaching materials and the personalization of learning, under the ethical and

specialized guidance of the teacher.

Table 7.5. Characterization of the prototypes developed

Type of prototype	**Average agreement with rubric**	**Strengths**
Applications	18,2	Educational relevance, logic, and design
Interactive games	17,8	Creativity, logic
Audiovisual (video, audio, animation)	18,4	Offline execution for rural areas
Criterion	**Average according to rubric**	**Level**
Creativity and innovation	4,1	Outstanding
Functionality and relevance	3,9	Achieved
Technical and pedagogical feasibility	4,3	Outstanding
Visual and audio presentation	3,8	Achieved

Regarding the products developed, there is evidence of high overall performance, with a weighted average of 18,1 out of 20 according to the analytical rubric used. This result suggests that the students have been able to translate the principles of design thinking into viable, contextually relevant initial technological responses. The comparison table between prototype types indicates that audiovisual products, including video, narration, animation, and audio material, obtained the highest average, 18,4, highlighting the quality of "offline" implementation with a perspective on rurality and bilingual cultural education. Applications stood out with an average of 18,2 for their educational relevance and design logic in interfaces and interaction flows with AI. Interactive games obtained an average of 17,8, standing out for their high level of creativity and logic. By criteria, the highest score was given to technical-pedagogical feasibility (4,3/5), followed by creativity and innovation (4,1/5), confirming that the students effectively applied divergent thinking and an exploratory approach to the use of AI as part of their creative process. Functionality and educational relevance received 3,9/5, and visual and sound presentation received 3,8/5, reaching levels that contribute to strengthening the didactic integration of emerging technologies and the aesthetic communication of the products.

DISCUSSION

The results show that guided integration of IAG and Design Thinking can lead to changes in how future early childhood teachers perceive IAG knowledge, skills, and pedagogical appropriation. The increase in average scores from 3,14 to 3,93, along with a maximum effect size (r = 1,00), suggests transformative learning in understanding the function of IAG, developing effective prompts, and using AI pedagogically to create educational materials. These findings are consistent with the literature that presents IAG as a resource that, when critically mediated by teachers, enhances personalization, feedback, and resource design (Farrelly & Baker, 2023; Ruiz-Rojas et al., 2023; Mittal et al., 2024; Bahroun et al., 2023; Giannakos et al., 2024; Samala et al., 2024). Likewise, the use of the post-then-pre retrospective design aligns with the logic proposed by Pratt et al. (2000) and Banghi et al. (2012), regarding the fact that the conceptual change produced by experience makes the subsequent self-assessment more valid than a baseline taken before students understand what it really means to know how to use IAG.

The transition from a superficial use of IAG as a simple "summary" tool to a more strategic skill, which requires precision and reflection on the quality of the instructions given to the model and the emerging categories "moving from the general to the specific," "recognition of the effort required," and "assessment of clarity and order" show that students begin to understand prompting as a metacognitive skill, in line with the conceptualization of prompt engineering as a high-level competency that requires planning, context, and purpose (Gordon, 2024; Mastery et al., 2025). This is consistent with UNESCO's (2023) recommendation to promote AI literacy that is not limited to instrumental use, but rather to its critical implementation with educational purpose.

In relation to the ethical dimension, the categories "verification and citations," "avoiding dependence and plagiarism," and "ethical and professional application" demonstrate explicit epistemic vigilance: not trusting the references generated, comparing sources, avoiding "copy and paste," and positioning IAG as a support, not a substitute for personal thinking. This pattern directly dialogues with the findings of Rana et al. (2025), who identify epistemic vigilance as a central axis in the integration of AI in the five phases of design thinking, as well as with the centrality of ethics in Kolhatin's (2025) narrative review. Likewise, the perception of the "double-sided" nature of AI—opportunity versus the risks of dependency or the impoverishment of development—described by Kölemen and Yıldırım (2025) appears here in the form of warnings against becoming subordinate to AI and preserving intellectual autonomy.

Regarding the integration of IAG and Design Thinking for the production of prototypes, the high ratings in creativity, technical-pedagogical feasibility, and educational relevance (overall average of 18,1/20 and outstanding scores in creativity and innovation and feasibility) are consistent with the results of Martínez (2025), who shows that teams with generative AI produce prototypes that are better rated in terms of originality and quality when integration is guided and structured. Similarly, the use of ChatGPT and Gemini as "design partners" in all phases of DT recalls the role of ChatGPT as a "design partner" described by Fischer et al. (2025), which favors the expansion of ideas and the synthesis of information as long as there is a human team to filter and contextualize. Likewise, offline audiovisual prototypes designed for rural and bilingual intercultural education contexts show that students do not simply replicate generic solutions, but apply the principles of empathizing, defining, and ideating in a situated manner (Brown, 2008; Razzouk & Shute, 2012), in line with the MIT Teaching + Learning Lab (2024) vision of AI as an accelerator of contextualized prototypes when the teacher's critical criteria are applied.

Although the present study does not have interaction traces as detailed as those analyzed by Yi et al. (2025), the students' reflections on the initial difficulty in formulating good prompts and the progressive improvement through practice and teacher modeling point in the same direction: the quality of the dialogue with AI depends on the sophistication of the questions. Finally, the projection of IAG toward future teaching practice in early childhood education reflects a pedagogical appropriation: AI is used to design materials, support planning, personalize learning, and accompany processes, but under ethical frameworks that are still under construction (Farrelly & Baker, 2023; Giannakos et al., 2024; Samala et al., 2024; Kolhatin, 2025). The IDB and UNESCO (2023) emphasize the importance of preparing students for a critical, rather than merely instrumental, use of these technologies. In this sense, the course analyzed provides contextualized evidence that, in an initial training program in Early Childhood Education and in a distance-learning modality, it is possible to simultaneously advance technical, reflective, and ethical competencies in IAG.

Regarding limitations, the retrospective post-then-pre design, although conceptually justified (Pratt et al., 2000; Banghi et al., 2012), relies on self-report and is highly susceptible to social desirability bias and memory reconstruction. The sample size, its non-probabilistic nature, and its focus on a single course limit the generalizability of the results, compared to quasi-experimental studies such as that of Martínez (2025) or longitudinal analyses such as those of Yi et al. (2025). The evaluation of the prototypes was conducted in the classroom, without external judges or more objective metrics related to the prototypes' purpose. Therefore, it is suggested that future research incorporate comparison groups, larger samples, traceability of interaction with AI, and longitudinal follow-up of the transfer to teaching practice.

CONCLUSIONS

The results show a significant increase in students' knowledge and skills, accompanied by a critical and pedagogical appropriation of AI. The experience not only enhanced technical capacity for interacting with generative tools but also promoted transformative learning focused on reflection, creativity, and professional ethics. In relation to the first specific objective, the students understood that prompting requires clarity, precision, and conscious effort, thereby confirming the effectiveness of the model implemented to develop metacognitive and digital skills in distance education contexts. Regarding the second specific objective, the findings indicate substantial progress towards a critical and ethical stance. The participants recognized the importance of validating information, avoiding technological dependence, and taking an active role in the content generated. Finally, regarding the third specific objective, the students developed products with high levels of creativity, relevance, and technical-pedagogical viability, demonstrating the practical application of Design Thinking principles. In addition, they projected the future use of AI as a support tool for the generation of materials, didactic planning, and the personalization of support for their students, thus consolidating the transfer of knowledge to real teaching scenarios.

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