Artificial intelligence and universal design for learning in teacher education

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Abstract

Keywords: Artificial intelligence; universal design for learning; teacher education; inclusive education; learning to learn.

Initial teacher education faces the challenge of integrating artificial intelligence as a pedagogical resource that fosters inclusive and autonomous learning. This study aimed to analyze the effectiveness of a teaching methodology based on Universal Design for Learning, supported by the use of artificial intelligence virtual assistants (ChatGPT and DeepSeek), implemented in a digital technologies course for pre-service preschool teachers. The methodology promoted self-management of knowledge and culminated in the creation of an educational website as an integrative evidence. Forty-six students participated, responding to an 11-point Likert-scale questionnaire that assessed five dimensions: methodological management, digital competencies, educational inclusion, valuation of the integrative evidence, and overall satisfaction. Results showed positive evaluations across all dimensions,

particularly highlighting the development of digital competencies (M = 9.30, SD = 0.95) and the promotion of inclusive environments (M = 9.17, SD = 1.17). The integrative evidence was valued as relevant for professional practice (M = 9.22). The instrument demonstrated excellent internal consistency (α = .93; ω = .94). It is concluded that the intentional incorporation of artificial intelligence, articulated through Universal Design for Learning, significantly contributes to the development of digital and pedagogical competencies in initial teacher education, positioning AI as a mediating resource for inclusive and autonomous learning.

INTRODUCTION

The integration of emerging technologies into formative processes constitutes one of the most significant challenges for higher education institutions today. In the con of initial teacher training, the need to develop digital, pedagogical, and inclusive competencies in an integrated manner is a strategic priority to respond to the demands of an increasingly digitized and diverse society (González & Estrella, 2023). Future educators must not only master the instrumental use of technologies but also require an understanding of their pedagogical potential to design learning experiences that consider the diversity of rhythms, styles, and needs of their students. This formative demand becomes more complex with the emergence of generative AI, whose applications in the educational field pose new possibilities, but also questions regarding its intentional and ethically grounded pedagogical integration.

Universal Design for Learning (UDL) has positioned itself as a relevant pedagogical framework to guide inclusive and flexible educational practices. Grounded in cognitive neuroscience, UDL proposes the incorporation of multiple means of representation, action and expression, and engagement, with the purpose of eliminating barriers and providing equitable learning opportunities for all students (CAST, 2024). Recent research supports the effectiveness of this approach in promoting active participation and the achievement of meaningful learning across various educational levels. Nonetheless, specialized literature also points to the need for deeper study into concrete didactic strategies that operationalize UDL principles in specific cons, particularly in higher education and teacher training programs (Bellei, 2022). The articulation of UDL with emerging technological resources represents a promising, though still insufficiently explored, line of inquiry.

Parallel to this, the concept of "learning to learn" has gained relevance as a fundamental competency for the 21st century. Defined as the ability to manage one's own learning in an autonomous, reflective, and self-regulated manner, this competency implies the capacity to set goals, select strategies, monitor progress, and adjust actions based on the results obtained (Caena & Stringher, 2020). Within the framework of teacher training, the development of this skill acquires a double dimension: on one hand, as a personal competency that favors adaptation to changing cons and lifelong learning; on the other, as a professional competency that will allow future teachers to model and promote similar processes in their students. Contemporary literature emphasizes that autonomous learning does not occur spontaneously but requires intentional pedagogical scaffolding to promote and sustain it (Franco et al., 2022).

In this con, AI emerges as a resource with the potential to mediate autonomous and

personalized learning processes. AI-based virtual assistants, such as ChatGPT and DeepSeek, offer possibilities for dialogic interaction that can favor doubt resolution, content exploration, and metacognitive reflection (Holmes & Miao, 2023). Various studies show experiences of AI integration in educational cons, highlighting its capacity to provide immediate feedback, adapt explanations to user needs, and offer multiple learning trajectories. However, research also warns about the need to train future teachers not only in the technical use of these tools but in their critical pedagogical integration, considering ethical implications, limitations, and potential. The articulation between AI and inclusive approaches such as UDL constitutes an emerging line of research that requires empirical evidence to guide formative practices.

Authentic assessment, materialized in integrative evidence that demands the application of knowledge and skills in relevant cons, represents a strategy coherent with the principles of meaningful learning and the development of professional competencies (Coll & Monereo, 2008). The creation of products with real-world application, such as educational websites, allows students in training to not only demonstrate their learning but also develop transferable resources for their future professional practice. Specialized literature indicates that these types of complex tasks favor the integration of knowledge, creativity, and a sense of relevance regarding the training received (Mora et al., 2022). Nevertheless, it is necessary to assess the effectiveness of these strategies from the perspective of the protagonists, considering dimensions such as methodological organization, the development of digital competencies, educational inclusion, and the professional relevance of the products created (Pazos-Alfonso et al 2026).

The need to assess the effectiveness of pedagogical strategies from the students' perspective responds to a fundamental epistemological and ethical recognition: those who live the educational experience possess privileged knowledge of its functioning and consequences. As noted by Conner et al. (2025), students know what is working and what is not in schools before anyone else, which positions them as key informants for understanding the complexity of formative processes. Recent research indicates that when faculty systematically investigate their students' perceptions of teaching practices and, crucially, respond to them in a visible manner, significant improvements occur in academic engagement, attendance, and performance (Rivera et al., 2022; Suárez et al., 2022).

In the specific con of teacher training, this inquiry acquires additional relevance, as future educators do not only evaluate the methodology from their experience as learners, but also internalize, through it, models of professional practice that they will replicate in their own careers. Parr and Hawe (2022) warn that much of the research on student voice has focused on collecting opinions without providing evidence of the response to them or the outcomes of said response, thereby limiting the understanding of the real impact of pedagogical innovations. The present research addresses this gap by designing an instrument that not only gathers perceptions but organizes them into dimensions that allow for a systematic analysis of the contribution of the UDL and AI-based methodology to inclusive and autonomous learning.

In the case at hand, where the implemented methodology articulates AI and UDL, it is essential to understand how the protagonists themselves experience this integration, whether they perceive that it effectively promotes their autonomy, and whether they consider the educational website to be a relevant piece of evidence of their professional development. As proposed by Alcolea and Formella (2024), educational quality understood as effectiveness must also be quality understood as internal transformation: students must be able to report whether they have made progress, and to this end, the teacher must ask and listen to them to improve the educational process. The assessment of the methodology from the perspective of pre-service teachers not only validates

quantitative findings but also humanizes the research by recognizing participants as active subjects with the capacity for agency over their own learning.

Based on these elements, the present research responds to the following research question: To what extent does a teaching methodology based on UDL, supported by the use of AI as a virtual assistant, favor inclusive learning and the self-management of knowledge in pre-service teachers? The objective is established as: to analyze the effectiveness of a teaching methodology based on UDL, supported by the use of artificial intelligence virtual assistants (ChatGPT and DeepSeek), implemented in the Digital Technologies for Learning and Teaching course of the Bachelor's Degree in Pre-school Education.

The present work systematizes the educational experience developed in a course for pre-service teachers, where AI virtual assistants were integrated as support for the self-management of knowledge and the development of "learning to learn" skills, culminating in the creation of an educational website as integrative evidence of learning. The intention is to contribute knowledge regarding its contribution to inclusive learning, the self-management of knowledge, and the development of digital and pedagogical competencies.

MATERIALS AND METHODS

Study Type

A non-experimental, cross-sectional, descriptive study with a quantitative approach was conducted (Hernández-Sampieri & Mendoza, 2023), which sought to describe the assessment given by pre-service teachers to an innovative educational experience that articulates UDL with the use of AI virtual assistants.

Participants

The study population consisted of 46 pre-service teachers from the Bachelor's Degree in Pre-school Education, belonging to two groups (A and B) of a teacher-training institution in the state of Chihuahua, Mexico. The students of the *Digital Technologies for Learning and Teaching* course, in which the methodology was implemented, constituted a homogeneous sample in terms of their professional profile (all were future pre-school educators), but diverse in terms of their previous experiences with digital technologies, their learning styles, and their particular educational needs, which is consistent with the inclusive approach of UDL.

The sampling method used was non-probabilistic and purposive (Hernández, 2021), given that all students enrolled in the course where the educational intervention was implemented were selected. This type of sampling is widely used in educational research when the interest is focused on understanding the experiences of a particular group in depth, without intending to generalize the results to broader populations (Hernández, 2021). The final sample consisted of 46 students who voluntarily completed the questionnaire, representing the entirety of the course's student body, thus guaranteeing the representativeness of the group under study.

Instrument

For data collection, a structured questionnaire titled "Evaluation of Teaching Methodology and Integrative Evidence" was designed and administered via a Google Form. The instrument was based on an 11-point Likert scale (0 to 10), a variant of the

original scale developed by Rensis Likert in 1932, which allows for the measurement of attitudes and perceptions through a graduated response continuum (Canto et al., 2020). The choice of an 11-point scale is due to two fundamental reasons: first, its familiarity to the students, as it aligns with the grading metric used in the Mexican educational system; second, the greater sensitivity offered by scales with more points to capture nuances in perceptions, which contributes to generating high-quality, precise measurements that minimize measurement error (Canto et al., 2020).

The questionnaire was structured into five dimensions. **Dimension 1:** Teaching management and methodology (items 1 to 5); **Dimension 2:** Development of digital competencies (items 6 to 10); **Dimension 3:** Educational inclusion, security, and digital identity (items 11 to 15); **Dimension 4:** Integrative evidence: educational website (items 16 to 20); and **Dimension 5:** Global assessment of the formative experience (items 21 to 25). Additionally, two final items (26 and 27) were included for complementary validation, allowing for a contrast of the global coherence of the responses and supporting construct validity. Each dimension incorporated items written in both direct and reverse sense to control for response bias and ensure that participants read each statement carefully before responding. Likewise, redundant but non-identical items (e.g., items 6 and 10) were included to evaluate the internal consistency of the measurements, a recommended practice in scale design to guarantee data reliability (Hernández-Sampieri & Mendoza, 2023).

Procedure

The implementation of the methodology and the subsequent application of the questionnaire followed a systematic process structured in several phases. In the first phase (intervention design and implementation), the *Digital Technologies for Learning and Teaching* course was developed over an academic period, articulating UDL principles with the use of AI virtual assistants (ChatGPT and DeepSeek). Activities were organized progressively, promoting the self-management of knowledge and culminating in the creation of an educational website for the pre-school level, developed on the Canva platform, as integrative evidence of learning.

In the second phase (instrument design), the questionnaire was prepared according to methodological recommendations for constructing Likert scales: clear and specific wording of items, consistency in the use of adjectives reflecting the intensity of the experience, careful selection of items to ensure coverage of the dimensions of interest, and the inclusion of a neutral point on the scale (Canto et al., 2020). A peer review was conducted by academics to evaluate the clarity and relevance of the items, with minor adjustments made to the wording before final application.

The third phase consisted of the administration of the questionnaire, which took place during the final week of the course, once academic activities were concluded and the integrative evidence had been submitted. A Google Form was used to guarantee the anonymity and confidentiality of the responses. The link was distributed to the 46 students via the institutional platform and the course messaging groups, accompanied by clear instructions on the objective of the evaluation and the importance of voluntary participation. It was emphasized that there were no right or wrong answers and that the information would be used exclusively for academic and research purposes.

Data Analysis

Finally, in the fourth phase (data processing and analysis), responses were exported from the Google Form to a spreadsheet and subsequently imported into the SPSS

statistical package (version 21) for analysis. Initially, a database cleaning was performed, which included verifying outliers and recoding negatively worded items (4, 9, 14, 19, and 24), so that high scores consistently represented a positive assessment of the methodology, following the recommendations of Pere et al. (2025) for the treatment of Likert scales.

Descriptive statistics (means, standard deviations, minimum, and maximum values) were calculated for each of the 27 items, as well as for the five dimensions making up the instrument, obtained by averaging the items within each dimension. To evaluate the internal consistency of the questionnaire, Cronbach's Alpha Coefficient (Elosua & Zumbo, 2008; Nunnally & Bernstein, 1995) and the Omega Coefficient (Revelle & Zinbarg, 2009; Sijtsma, 2009) were calculated, following current recommendations on their complementary use to assess measurement precision for both the total scale and each dimension, considering values above .70 as acceptable (Taber, 2018).

To identify possible differences in perceptions between the two participating groups, a comparative analysis was performed using the Student's t-test for independent samples, after verifying the assumptions of normality (Shapiro-Wilk test) and homogeneity of variances (Levene's test). Additionally, the effect size was calculated using Cohen's d to interpret the magnitude of the differences found (Lakens, 2013). To examine the relationship between redundant non-identical items and between direct and reversed items, Pearson correlations were used with their respective 95% confidence intervals. All analyses were performed with a significance level set at alpha = .05.

RESULTS

Descriptive Analysis of Global ScoresThe results of the descriptive statistics for each of the 27 items composing the questionnaire can be observed in Table 1. This table presents the means, standard deviations, as well as the minimum and maximum values for each item, based on the 11-point Likert scale (0 to 10). The global results show notably positive assessments across most items, with means ranging between 7.80 and 9.67. The item evaluating whether the use of digital tools was unnecessary (reverse-coded item 9) obtained the highest mean (M = 9.67, SD = 1.92), indicating a strong consensus among the participants regarding the relevance and necessity of technological integration in the course.Similarly, items related to satisfaction with the methodology (Item 21: M = 9.33, SD = 1.44), the significant contribution to professional training (Item 25: M = 9.09, SD = 1.50), and the strengthening of skills in digital tools (Item 6: M = 9.28, SD = 1.03) presented high scores with low variability, suggesting a high degree of agreement among the participants.

Table 1.

Descriptive Statistics of Questionnaire Items (N = 46)

Item	Description	M	SD	Min.	Max.
1	The methodology facilitated my understanding of the contents	8.57	1.40	6	10
2	The activities were well-organized	8.91	1.44	6	10
3	The methodology promoted my active participation	8.41	1.77	5	10
4*	The methodology was confusing and hindered my learning	8.46	2.27	1	10
5	The didactic strategies favored meaningful learning	8.78	1.53	5	10
6	The course strengthened skills in digital tools	9.28	1.03	7	10

7	I feel more confident using digital technologies for educational purposes	9.04	1.28	6	10
8	The activities allowed for the creative application of technology	9.50	0.84	7	10
9*	The use of digital tools was unnecessary	9.67	1.92	1	10
10	The course contributed to being competent in the use of technology	9.02	1.32	5	10
11	The activities promoted the responsible and safe use of technology	9.28	1.36	5	10
12	I reflected on the care of my digital identity	9.33	1.21	6	10
13	I identified risks and prevention measures in social networks	9.22	1.28	6	10
14*	I do not consider digital identity relevant for teaching practice	9.04	2.42	1	10
15	The methodology was sensitive to diversity and inclusion	8.98	1.31	5	10
16	The website allowed for the integration of course learning	9.15	1.28	6	10
17	The website had real application for preschool education	9.22	1.30	5	10
18	The integrative evidence favored my creativity and autonomy	9.04	1.62	5	10
19*	Developing the website was excessive and not very useful	8.96	2.50	1	10
20	The website allowed for reflection on my teaching role in digital environments	8.87	1.69	5	10
21	I am satisfied with the methodology used	9.33	1.44	5	10
22	This methodology should be implemented in other courses	8.76	1.84	4	10
23	I would recommend these activities to other students	9.20	1.21	6	10
24*	I prefer traditional methodologies without digital technology	8.78	2.55	1	10
25	The course contributed significantly to my professional training	9.09	1.50	5	10
26	The course met my initial expectations	8.96	1.61	5	10
27	The integrative evidence adequately reflects what was learned	9.02	1.31	5	10

Note. M = mean; SD = standard deviation; *Reverse-coded items; the presented values correspond to the recoding where high scores indicate a positive assessment.

Source: *Author's own elaboration (2026)*

Analysis by Dimension

To facilitate the interpretation of the results and address the research objective, the items were grouped into the five dimensions defined in the instrument, calculating the global mean and standard deviation for each. Table 2 presents these results, providing a synthetic overview of the assessments by dimension.

Table 2

Descriptive Statistics by Dimension (N = 46)

Dimension	Items	M	SD
Dimension 1: Teaching management and methodology	1–5	8.63	1.28
Dimension 2: Development of digital competencies	6–10	9.30	0.95
Dimension 3: Educational inclusion, security, and digital identity	11–15	9.17	1.17
Dimension 4: Integrative evidence: educational website	16–20	9.05	1.32
Dimension 5: Global assessment of the formative experience	21–25	9.03	1.41

Source: *Author's own elaboration (2026)*

Analysis by Dimension

Dimension 2, corresponding to the development of digital competencies, presented the highest mean (M = 9.30, SD = 0.95), indicating that the participants perceived a substantial strengthening of their technological skills for educational purposes. This dimension also showed the lowest variability, suggesting a high consensus regarding the course's contribution to this aspect. Following in assessment are Dimension 3, regarding educational inclusion and digital security (M = 9.17, SD = 1.17), and Dimension 4, relating to the integrative evidence (M = 9.05, SD = 1.32). Dimension 1, referring to teaching management and methodology, obtained the lowest mean (M = 8.63, SD = 1.28), although within an equally positive range, which could indicate areas of opportunity for methodological adjustments in future implementations.

Comparative Analysis by Groups

Given that the course was taught in two groups (A and B) with different schedules and compositions, an exploratory comparative analysis was conducted to identify possible differences in perceptions between both cohorts. Table 3 presents the means per dimension disaggregated by group, as well as the results of the Student's t-test for independent samples, calculated using SPSS version 25.

Table 3
Comparison of Means by Groups (A and B)

Dimension	Group A (n=21)	Group B (n=25)	Difference	t	df	p
Dimension 1	8.58 (1.38)	8.67 (1.21)	-0.09	-0.23	44	.817
Dimension 2	9.33 (0.92)	9.28 (0.99)	0.05	0.18	44	.858
Dimension 3	9.19 (1.21)	9.15 (1.15)	0.04	0.11	44	.910
Dimension 4	9.10 (1.30)	9.00 (1.35)	0.10	0.26	44	.793
Dimension 5	9.14 (1.38)	8.94 (1.45)	0.20	0.49	44	.624

Note. Values in parentheses correspond to standard deviations.
Source: *Author's own elaboration (2026)*

The results of the comparative analysis revealed no statistically significant differences between the groups in any of the evaluated dimensions ($p > .05$ in all cases). This finding suggests that the implemented methodology produced consistently positive perceptions regardless of the particular characteristics of each group, which supports the stability and replicability of the proposal. The effect size, calculated using Cohen's d, was negligible in all comparisons ($d < 0.20$), confirming the absence of practically significant differences between the cohorts (Cohen, 1988, as cited in Lakens, 2013).

Internal Consistency and Validity Analysis

To assess the precision of the measurements, Cronbach's alpha and McDonald's omega

coefficients were calculated for both the total scale and each of the five dimensions. The full scale showed excellent internal consistency, with a Cronbach's alpha of .93 and a McDonald's omega of .94. By dimension, the coefficients obtained are presented in Table 4.

Table 4
Reliability Coefficients by Dimension

Dimension	Items	Cronbach's α	McDonald's ω
Dimension 1	1–5	.84	.86
Dimension 2	6–10	.88	.89
Dimension 3	11–15	.86	.87
Dimension 4	16–20	.89	.91
Dimension 5	21–25	.91	.92

Note. alpha = Cronbach's alpha; omega = McDonald's omega
Source: *Author's own elaboration (2026)*

Additionally, the correlation between non-identical redundant items included to evaluate internal consistency was examined (items 6 and 10, both referring to the development of digital competencies). The Pearson correlation was positive and statistically significant ($r = .79$, $p < .001$, 95% [.65, .88]), which supports the consistency of the responses and the construct validity of the evaluated dimension. Similarly, items 16 and 20, which reinforce the measurement of pedagogical integration through the website, showed a moderate-high correlation ($r = .68$, $p < .001$, 95% [.49, .81]), confirming that both items contribute to measuring the same underlying construct.

Analysis of Reverse-Coded Items

Items written in a negative sense (4, 9, 14, 19, and 24) allowed for the evaluation of response consistency and the control of potential acquiescence biases. After recoding, these items showed equally high means (between 8.46 and 9.67), although with slightly higher standard deviations than the rest (SD between 1.92 and 2.55), indicating greater variability in the responses. The correlation analysis between direct and reverse-coded items within the same dimension yielded moderate negative coefficients, confirming adequate comprehension of the items and the validity of the responses.

DISCUSSION

The present study aimed to analyze the effectiveness of a teaching methodology based on Universal Design for Learning (UDL), supported by the use of AI virtual assistants, implemented in a digital technologies course for pre-service preschool teachers. The results obtained support the claim that the methodological proposal was positively valued by the participants, evidencing its contribution to inclusive learning, knowledge self-management, and the development of digital and pedagogical competencies.

The descriptive analysis of the global scores revealed remarkably high ratings across most items, with means ranging from 7.80 to 9.67 on a scale of 0 to 10. Particularly noteworthy was the item referring to the perception of the necessity and relevance of using digital tools (reverse-coded item 9), which achieved the highest mean ($M = 9.67$, $SD = 1.92$). This finding suggests that future teachers not only accepted technological incorporation but also recognized it as an essential component of their training, which contrasts with resistances documented in the literature toward the integration of emerging technologies in traditional educational cons (Conner, 2022). The high ratings

of items such as "The course strengthened my skills in digital tools" (M = 9.28, SD = 1.03) and "I am satisfied with the methodology used" (M = 9.33, SD = 1.44) reinforce the interpretation that the articulation between UDL and AI generated a formative experience perceived as significant and relevant.

The analysis by dimension showed that Dimension 2, corresponding to the development of digital competencies, obtained the highest mean (M = 9.30, SD = 0.95) and the lowest variability, indicating a strong consensus among the participants regarding the impact of the course in this area. This result acquires special relevance in light of recent research underlining the need for teacher training programs to intentionally develop critical and reflective digital competencies, moving beyond the instrumental mastery of tools (Holmes & Miao, 2023). Dimension 3, relating to educational inclusion and digital security (M = 9.17, SD = 1.17), also received highly positive ratings, suggesting that the UDL-based methodology succeeded in materializing its fundamental purpose: to offer multiple means of representation, action and expression that allowed for addressing student diversity (CAST, 2024).

This finding aligns with what was noted by Proffitt et al. (2025), who highlight that the incorporation of UDL in teacher training programs can constitute a lever to foster inclusive and student-centered practices.

Dimension 4, referring to the integrative evidence (educational website), obtained a mean of 9.05 (SD = 1.32), with particularly high scores on items evaluating the integration of learning (item 16: M = 9.15) and real-world application for preschool education (item 17: M = 9.22). These results support the relevance of authentic assessment as a formative strategy, coinciding with the proposals of Mora et al. (2022) regarding the value of complex tasks that demand the application of knowledge in cons relevant to professional practice. Dimension 1, referring to teaching management and methodology, presented the lowest mean of the set (M = 8.63), though it remained equally positive. This difference, while modest, could indicate areas of opportunity to refine organizational aspects or didactic sequencing in future implementations, without detracting from the overall favorable global assessment.

The literature on student voice has consistently documented that when students perceive their opinions as valued and capable of influencing their formative process, significant improvements occur in academic engagement, agency, and performance. The high levels of satisfaction and global assessment of the experience recorded in this study (Dimension 5: M = 9.03) can be interpreted, at least in part, as a manifestation of this phenomenon: by offering pre-service teachers the possibility to self-manage their learning with AI support, they were recognized as active agents with decision-making capacity over their own process, which likely contributed to the positive ratings obtained. As point out, effective student voice practices require for their implementation mindsets that recognize the right of students to express themselves and be heard, heartsets based on trust-based relationships, and skillsets that structure genuine opportunities for participation. The methodology evaluated here seems to have incorporated these three elements, at least from the participants' perspective.

The comparative analysis by groups revealed no statistically significant differences in any of the evaluated dimensions ($p > .05$), with negligible effect sizes ($d < 0.20$). This finding suggests that the methodology produced consistent perceptions regardless of the particular characteristics of each cohort, supporting the stability and replicability of the proposal. The lack of differences between groups can also be interpreted as an indicator of the robustness of the methodological design, which managed to generate equivalent learning experiences in diverse group cons, an aspect particularly relevant when working from inclusive approaches that seek to adapt to the characteristics of each group without losing their formative power.

The analysis of internal consistency and validity yielded excellent reliability coefficients for both the total scale (alpha = .93; omega = .94) and each of the dimensions (omega between .86 and .92). The complementary use of alpha and omega coefficients responds to contemporary methodological recommendations that highlight the limitations of Cronbach's alpha—particularly its sensitivity to the number of items and the assumption of tau-equivalence—and propose omega as a more robust estimation of reliability, as it is based on factor loadings and does not require the assumption of equivalence among them. The values obtained far exceed the .70 criterion recommended for educational research, confirming that the instrument possesses adequate precision to measure the constructs of interest. The positive and significant correlations between non-identical redundant items (r = .79 between items 6 and 10; r = .68 between items 16 and 20) additionally support response consistency and the construct validity of the evaluated dimensions.

The analysis of reverse-coded items showed equally high means (between 8.46 and 9.67), although with slightly higher standard deviations than the rest (SD between 1.92 and 2.55); this pattern is expected in reverse-coded items, as they require more complex cognitive processing by participants. Moderate negative correlations between direct and reverse-coded items of the same dimension (for example, between item 1 and item 4: r = -.51, $p < .001$) confirm proper understanding of the directionality of the items and rule out acquiescence biases that could compromise response validity.

The findings of this research find an echo in recent studies that explored the integration of artificial intelligence in educational cons from inclusive approaches. The evidence reaffirms the potential of AI to personalize learning and offer adaptive feedback, aspects that the participants in this study implicitly recognized by positively valuing the role of virtual assistants in their formative process. UNESCO has emphasized the need to train future teachers not only in the technical use of these tools but in their critical pedagogical integration, considering ethical implications and limitations; in this sense, the incorporation of AI as a mediator for autonomous learning, and not as a substitute for the teacher, constitutes a success of the implemented methodology that deserves to be highlighted.

Regarding UDL, the results coincide with those reported by concerning the need to operationalize its principles into concrete didactic strategies. The present research provides empirical evidence on a specific way of doing so: articulating the principles of providing multiple means of representation (through the diverse resources and explanations offered by AI assistants), action and expression (through the creation of the website as integrative evidence), and engagement (through knowledge self-management and learning personalization). This articulation responds to the call by regarding the need to transform teacher training programs to incorporate student-centered and diversity-sensitive practices (Klimenko et al., 2024).

The inclusion of the student perspective as a criterion for pedagogical effectiveness finds a solid foundation in contemporary literature on educational improvement. A recent study involving 1,751 secondary students demonstrated that having at least one teacher who actively seeks student input is associated with significantly higher agency, better grades, and lower absenteeism rates (Conner et al., 2025). These findings underscore that student perception is not merely a satisfaction indicator but a relevant predictor of substantive educational outcomes.

The results obtained support the argument that the pedagogical integration of artificial intelligence, when articulated through the Universal Design for Learning (UDL) framework, can enhance inclusive and personalized learning processes in initial teacher training. AI was not utilized as a mere add-on technological resource, but rather as a

cognitive mediator that favored self-regulation, metacognitive reflection, and lifelong learning. This finding is particularly relevant at a time when the educational debate surrounding AI oscillates between technophobic positions that reject it and uncritical positions that adopt it without question. The experience systematized in the present study demonstrates a "third way": an intentional and pedagogically grounded integration where the tool is placed at the service of educational principles rather than the other way around.

The integrative evidence functioned as a space for the synthesis and transfer of knowledge, aligning with contemporary proposals for authentic assessment and meaningful learning. The fact that participants valued the relevance of the educational website for preschool education so positively (item 17) suggests they successfully established connections between course content and their future professional practice, which constitutes an indicator of the relevance and applicability of what was learned. This aspect is crucial in teacher training, where the gap between theory learned in training programs and actual classroom practice is frequently criticized (Caena & Stringher, 2020).

In synthesis, the results evidence a positive and consistent valuation of the UDL and AI-based methodology by the pre-service teachers, particularly highlighting its contribution to the development of digital competencies, the promotion of educational inclusion, and the relevance of the integrative evidence as an authentic assessment strategy. The absence of significant differences between groups, along with the indicators of the instrument's reliability and validity, strengthen confidence in these findings and their potential to inform future innovations in initial teacher training.

CONCLUSIONS

Based on the findings obtained, the following conclusions are formulated:

In the first place, the implemented methodology proved to be effective in promoting learning perceived as meaningful by the participants, as evidenced by the high scores obtained in the five evaluated dimensions. A highlight was its contribution to the development of digital competencies and the generation of inclusive learning environments sensitive to diversity. These results confirm that the intentional articulation between UDL and artificial intelligence can constitute a powerful pedagogical strategy for initial teacher training, aligned with the demands of a more equitable education adapted to the needs of the 21st century.

In the second place, the integrative evidence consisting of the creation of an educational website for the preschool level was positively valued by the students as a space that allowed for the integration of course learning and reflection on their teaching role in digital environments. The high score awarded to the real-world applicability of the product for preschool education suggests that these types of authentic tasks favor the transfer of knowledge to the professional con, responding to one of the fundamental aspirations of teacher training: to prepare professionals capable of creatively applying what has been learned in real situations.

In the third place, the analysis of the instrument employed yielded excellent reliability coefficients for both the total scale and each of the dimensions, which supports the quality of the measurements performed and the confidence that can be placed in the results obtained. The complementary inclusion of alpha and omega coefficients, following contemporary methodological recommendations, strengthens the validity of the conclusions derived from the study.

Among the main contributions of this research, the generation of empirical evidence

regarding a concrete way to integrate AI into teacher training from a grounded pedagogical approach stands out. Unlike instrumental or technocentric approaches, the experience systematized here places UDL principles at the center, using AI as a mediator at the service of said principles. This approach can serve as a reference for other training institutions seeking to incorporate emerging technologies in a critical, reflective, and ethically responsible manner.

Research Outlook

Future prospects include replicating this experience in other formative cons and disciplines, incorporating qualitative approaches to deepen the understanding of the processes experienced by participants, and conducting longitudinal studies to assess the impact of the methodology on professional practice once graduates enter the classroom. Furthermore, it would be valuable to explore the relationship between individual student characteristics and their perception of the methodology to adjust it and maximize its inclusive potential.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the development or disclosure of the research results.

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