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Training of Future Teachers in the Binomial Universal Design for Learning and Technologies for Inclusive Education

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Abstract

Teacher education plays a key role in promoting inclusion and educational equity, especially in contexts characterised by increasing socio-cultural diversity and technological advancement. In this framework, Universal Design for Learning (UDL) and digital technologies are presented as complementary and innovative strategies to create accessible, flexible, and motivating learning environments for all students. The study analysed the impact of UDL-focused learning activities and integrated Information and Communication Technologies (ICT). A comparative tool was applied before and after the intervention to measure the level of knowledge, perception, and digital competence of prospective teachers. Statistical analyses were carried out to evaluate the changes obtained. Findings reveal significant improvements in knowledge about UDL, as well as positive perceptions of ICT as a resource for inclusion. Participants demonstrated a greater understanding of UDL principles and strengthened their digital competences to design educational proposals adapted to diversity. The research confirms the value of integrating UDL and ICT in teacher training, fostering inclusive educational practices. It highlights the need to strengthen training programmes that respond to the current challenges of the education system.

Keywords: UDL; technologies; digital competences; inclusive education

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1. Introduction

In the current educational context in which we find ourselves, characterised by the diversity of learning styles and the incorporation of technologies, it is necessary for teachers and future teachers to receive adequate and up to date university training in digital competences and teaching strategies that will bring them closer to the diverse students they will be teaching.

To make optimal use of technologies, they need to enable the individualization of learning through the diversity of resources available and in accordance with the multiple ways of learning. Some authors [1] point out that, although teachers recognise the importance of having digital competences, training programmes do not provide adequate preparation for integrating technology affectively into teaching.

Along these lines, it should be noted that university teachers recognise that they have a low or medium-low level of digital competence, especially in areas related to the evaluation of educational practice. This digital skill gap may limit teachers' ability to implement inclusive and adaptative strategies in the classroom [2].

With these premises in mind, we wanted to find out whether education students are aware of Universal Design for Learning (UDL) and the support they can receive to be able to develop technology use into their future classrooms.

After carrying out a series of activities in the classroom, we wanted to check the change that occurred in future teachers after implementing these activities, in which they develop the UDL model with technologies. In this way, the incorporation of tools such as Artificial Intelligence, virtual reality, or escape-rooms enrich the teaching–learning process, as well as offer multiple ways of learning in line with learning theories and UDL principles.

1.1. The Binomial Technology and Universal Design for Learning (UDL)

The UDL is configured in the current educational framework as a comprehensive pedagogical approach aimed at building inclusive school environments that guarantee the participation of all educational agents. From this perspective, personalised teaching is promoted by mobilizing multiple forms of representation, expression, and engagement, with the aim of equitably addressing the diversity of students' needs [3–6].

Authors [7,8] point out that this model goes far beyond the traditional way of understanding attention to diversity and introduces an innovative dimension focused on motivation as an essential driver of meaningful learning. This incorporation of universal accessibility promoted by the SAD is in line with the psycho-pedagogical currents of Piaget and Vygotsky, emphasising both the personalisation of learning and the socio-cultural and contextual dimension of educational development [6]. This is a transformation that allows for individual attention based on principles of equity, inclusion, and curricular flexibility [3,9]. Numerous studies have also highlighted the effectiveness of complementing the SAD with technologies, as they show improvements in student learning outcomes [10,11]. It would therefore imply a redefinition of the curriculum, understood as a transformation of traditional teaching materials towards dynamic, functional, and creative digital resources.

The incorporation of digital technologies in this framework is not merely instrumental but is configured as the backbone of the UDL teaching proposal. Technologies are positioned as catalysts for inclusive educational experiences, enabling the creation of interactive, adaptive, and motivating learning environments [12]. In this way, technology not only complements pedagogical processes but also transforms them structurally, enabling active and flexible methodologies that contribute to the elimination of barriers to learning and participation.

Adapting teacher training in digital competences, in the knowledge and implementation of the UDL, as well as requiring institutional support for its effective implementation [13], is a task to be encouraged. In this way, we understand that the technology—UDL binomial does not constitute a simple instrumental combination; it is an integral pedagogical framework that transforms educational processes and places diversity as a value, not as an obstacle. This synergy requires a profound reconceptualisation of the curriculum, teaching roles, and teaching methodologies, in line with an inclusive, participatory, and motivating paradigm.

1.2. Teacher Training in Technology and UDL: Towards an Inclusive and Innovative Pedagogy

Focusing our attention on teacher training is a fundamental pillar to guarantee a change towards quality, equity, and innovation in education systems. Today, the emergence of school contexts marked by socio-cultural diversity, inequalities of access, and technological change has highlighted the need to rethink training programmes from an integrated perspective that articulates digital, pedagogical, and ethical competences [14,15].

Strengthening inclusive initial teacher education requires a holistic vision that transcends the technical dimension of inclusion to be situated in an ethical logic of knowledge construction oriented towards educational justice [16]. This conception implies adopting open, collaborative, and transformative pedagogical approaches that integrate student diversity as an educational value [14,17,18].

The teacher training process must therefore be based on active methodologies, transformative approaches, and innovative pedagogical principles that enable the construction of democratic, participatory, and inclusive learning environments [19–21]. In this framework, the UDL does not only present a teaching methodology, but also an educational philosophy that orients teacher training towards the creation of effective, diversity-sensitive, and equity-based support systems in which all students have a place.

In this sense, teacher training within the framework of UDL, supported by the strategic use of technologies, represents a response in line with the needs and demands of today's society. Authors [22] point out that the construction of inclusive, interactive, and flexible learning environments requires future education professionals to be able to design didactic proposals adapted to the characteristics of the students, using digital resources not only as instrumental tools, but also as means of pedagogical transformation.

In this line, teacher training should be oriented towards the development of transversal competences that integrate not only the technical mastery of technologies, but also their didactic, communicative, and evaluative application [23,24]. The challenge is not only to teach how to use technology, but also to train critical, creative, and ethically committed professionals for inclusion and educational justice. Authors [25] confirm that adequate digital literacy is essential to adapt to the new educational and social realities; although there is a greater incorporation of technologies after the pandemic and teachers perceive themselves as having a moderate mastery of their digital competences, their ability to develop these competences in students is still limited, especially in the field of digital pedagogy.

The high valuation by students of digital environments that allow multiple forms of access, knowledge production, and participation in the work carried out by the authors [26] indicates a progressive appropriation of the principles of UDL as a foundation for their future professional practice. Therefore, promoting the convergence between UDL and technology in initial teacher training not only responds to a technical–didactic demand, but also constitutes a political and ethical requirement to transform the school into a space for democratic participation where diversity is respected and there is meaningful learning for all [20,27].

2. Materials and Methods

2.1. Objective

The main objective of the study was to evaluate the impact of UDL through the use of Information and Communication Technologies (ICT) in teaching–learning processes, by means of comparative analyses applied with a specialized evaluation tool.

Based on this objective, the following hypotheses were proposed:

- Null hypothesis (H0) = the implementation of UDL in combination with the use of technologies does NOT improve the ways of representing information with technologies, nor does it promote the expression of their learning in a more effective way, or increase the commitment towards the use of technology.
- Alternative hypothesis (H1) = the implementation of UDL in combination with the use of technologies improves the ways of representing information with technologies, promotes the expression of their learning more effectively, and increases the commitment towards the use of technology, reflecting a satisfactory increase after integration.

2.2. Design and Participants

The research design focused on a quantitative, quasi-experimental, pre-test/post-test approach. This approach allowed us to evaluate the effects of the pedagogical intervention that was carried out in order to assess the intervention.

A total of 386 university students participated, of whom 237 (61.4%) were studying for a degree in Primary Education, 101 (26.2%) for a degree in Pedagogy, and 48 (12.4%) for a degree in Early Childhood Education. These participants were enrolled at an Andalusian university during the 2024–2025 academic year. However, although the sample is not representative at the international level, but rather at the national/regional level, its heterogeneity in terms of degrees, educational levels, and age has provided a wealth of information that has allowed for a realistic and valid approach to the study. However, this aspect is recognised as a limitation to the possibility of generalising the results, which could be extended to larger populations in future research. The subjects were selected non-probabilistically and by convenience, enrolled in the subjects 'Information and Communication Technologies Applied to Primary Education', 'Educational Technology', and 'Information and Communication Technologies Applied to Early Childhood Education'.

Participants from the Primary Education degree were enrolled in the first year, those from the Pedagogy degree in the second year, and those from the Early Childhood Education degree in the fourth year. Their ages ranged from 18 to 30 years, with a mean of 19.96 years and a standard deviation of 1.82 years.

With regard to the students' previous ideas and knowledge of UDL, 54.9% indicated that they had no knowledge of it, while 45.1% answered in the affirmative. Similarly, 8.5% mentioned having had previous experience with UDL, while 91.5% said they had no experience with the model under study.

Regarding students' use and perception of technologies, the vast majority, 91.2%, believed that these tools promote inclusion in the classroom, compared to the 8.8% who disagreed with this statement.

In addition, they were asked about the relationship between the use of UDL and attention to diversity through technologies. A total of 78.2% responded affirmatively, while 21.8% did not.

These results support the relevance of the study and highlight the importance of evaluating the impact of UDL and technologies in education, as well as training students based on this approach.

2.3. Assessment Instrument

The assessment instrument used was redesigned and validated by the authors, as it appears in [26], which provides the validation process that was carried out for its subsequent implementation. This instrument is a tool specialized in UDL and technologies and consists of a total of 3 dimensions and 16 items. It was provided to students as an online questionnaire using a Likert scale with 6 possible options, where 1 is "strongly disagree" and 6 is "strongly agree".

The evaluation tool was applied at two key moments: before starting the UDL intervention and use of technologies (pre-test) and after the intervention (post-test), allowing a comparison between the different moments.

Dimension 1 is made up of those items that focus on studying the way students represent information by means of technology. Dimension 2 items analyse how students can demonstrate or express their learning using technology. And dimension 3 integrates those items related to the commitment or involvement generated by the use of technology (see Table 1).

Table 1. Assessment instrument.

Dimension	Items
Multiple forms of representation (R)	• You know digital strategies to help in the construction of learning strategies, such as metacognition tools, online learning journals, or digital concept maps. • You promote the use of interactive platforms and gamified resources to encourage learner autonomy. • You incorporate real and relevant examples using digital simulations, online case studies, and virtual or augmented reality into university experiences. • You select digital resources that foster learner motivation, such as interactive narratives, game-based learning, or gamified challenges. • You implement tools that promote self-regulated learning and immediate feedback, such as digital rubrics, self-assessment platforms, and reflection wizards. • You use collaborative digital tools (shared documents, virtual boards, online teamwork environments) to foster interaction between learners. • You use digital strategies to highlight main ideas, such as animated presentations, automatic summaries, or collaborative annotation tools.
Multiple forms of action and expression (AE)	• You are familiar with technological tools that provide alternatives to visual information, such as audio descriptions or screen readers. • You are familiar with digital tools to guide learning, such as interactive tutorials, educational artificial intelligence, or personalised learning assistants. • You are familiar with digital platforms and apps that allow learners to express themselves in different ways, such as discussion forums, video editors, digital drawing tools, or interactive storytelling. • You use software to support accessibility in electronic materials, such as screen readers, text-to-speech converters, and advanced spell checkers. • You are familiar with digital platforms that facilitate content diversity and enable personalised teaching according to the needs of each learner.
Multiple forms of engagement (E)	• You use technologies to minimize distractions, such as time tracking apps, concentration modes on devices, or blocking tools for non-learning-related sites. • You emphasise the importance of the goals to be achieved through digital progress boards, virtual badges, or challenge-based learning strategies. • You tailor learning objectives through adaptive platforms that adjust levels according to each learner's ability. • You use technologies to provide individualized support, such as virtual assistants, adaptive learning tools, or digital tutors.

2.4. Procedure

This study was carried out in 4 phases: diagnosis, intervention, evaluation, and data analysis. The intervention design is based on the combination of UDL and technologies, conceived as a pedagogical framework rather than as a set of educational strategies or tools. This integration stems from the need to train future teachers in skills that enable them to create inclusive learning environments. From this perspective, UDL is structured around design and planning based on the inclusive principles of representation, action and expression, and engagement. Each principle was developed through pedagogical activities supported by technology as an educational resource to comply with these principles, promoting accessibility and usability, student motivation, and the personalisation of learning.

Technologies, therefore, are not a complementary element, but rather form part of the design structure, as they enable the principles of DUA to be put into practice through gamification, digital assistants, or virtual simulations, among others.

Likewise, both the collection of data and its subsequent analysis were based on a questionnaire structured around the three main dimensions of DUA, which allowed a direct relationship to be established between these dimensions and the effectiveness of the intervention, thanks to the pre-test and post-test.

In the first phase (diagnosis), students were asked a series of questions to find out whether they were familiar with the term UDL and whether they had had any experience with it during their training or had ever applied it. Subsequently, they were given the evaluation instrument as a pre-test with the aim of obtaining an initial knowledge of the above-mentioned dimensions, focusing on their experiences during their training on the use of SAD and technologies. This phase allowed us to identify the real needs and expectations of the participants before implementing the intervention.

The second phase (intervention) consisted in the integration of didactic and pedagogical content related to the principles of UDL, emphasising how the use of applied technologies can promote more inclusive and diverse teaching practices. This instructional sequence was implemented over the course of four sessions, during which interactive activities were designed to foster multiple means of representation, expression, and engagement through the use of digital technologies. To facilitate the development of these activities and support student learning, a variety of digital resources were employed, including the Blackboard virtual learning platform and content adapted to address the individual needs of students.

The intervention was structured across four sequential sessions. The first session was dedicated to a lecture-style introduction, aimed at presenting the key content and providing a theoretical foundation concerning UDL principles and associated concepts. In the second session, students were exposed to examples of educational resources that effectively incorporated UDL strategies, enabling them to analyse and reflect on best practices. During the third session, participants engaged in the design and development of their own instructional materials, integrating UDL principles and technological tools to address learner variability and promote inclusive learning environments. The fourth and final session was devoted to the presentation and collective discussion of the materials produced. This final stage enabled students to share outcomes, critically reflect on the learning process, and draw informed conclusions regarding the application and impact of UDL in educational contexts.

During the third phase (evaluation), once the intervention was finished, the evaluation instrument was applied again, but as a post-test in order to know its effect and compare the results with those obtained initially.

During the fourth phase (data analysis), we proceeded to store the data in the professional statistical program SPSS v. 29, thus allowing us to determine the significant differences between the two tests, and to measure the effectiveness implemented. The following statistics were performed: a reliability scale using Cronbach's Alpha, a normality test, a descriptive analysis of the tests carried out, and the Wilcoxon test to accept or reject the H0.

3. Results

3.1. Reliability Scale

In order to determine the internal consistency of the assessment instrument used in this research, the Cronbach's alpha coefficient was calculated for each of the dimensions, as well as for the entire instrument (see Table 2).

Table 2. Cronbach's alpha reliability scale.

	Cronbach's Alpha	Number of Items
R dimension	0.888	7
AE dimension	0.878	5
E dimension	0.727	4
Total score	0.906	16

Note: Values obtained from the reliability index.

The results reflected that all dimensions reached acceptable levels for reliability, given that they were above 0.70. The R and AE dimensions obtained high values, suggesting a good internal consistency due to their proximity to 0.9. However, E dimension obtained a more moderate level, although it was within the acceptable range. Furthermore, in the total computation of the assessment instrument, Cronbach's alpha was 0.906, thus indicating an excellent reliability of the results of the study.

3.2. Normality Test

In order to correctly apply the inferential statistical tests, a normality analysis was performed on the scores obtained in the pre-test and post-test. These determined the use of parametric tests. The normality test was calculated using Kolmogorov–Smirnov (with Lilliefors correction) and Shapiro–Wilk (sensitive in detecting deviations from normality) (see Table 3).

Table 3. Pre-test and post-test normality test.

	Pre-Test						Post-Test					
	Kolmogorov–Smirnov [1]			Shapiro–Wilk			Kolmogorov–Smirnov [1]			Shapiro–Wilk		
	Statistical	gl	Sig.	Statistical	gl	Sig.	Statistical	gl	Sig.	Statistical	gl	Sig.
R dimension	0.216	386	<0.001	0.709	386	<0.001	0.219	386	<0.001	0.761	386	<0.001
AE dimension	0.057	386	0.005	0.992	386	0.047	0.103	386	<0.001	0.941	386	<0.001
E dimension	0.112	386	<0.001	0.936	386	<0.001	0.161	386	<0.001	0.870	386	<0.001

[1] Lilliefors significance correction.

The results show that, in all dimensions, the values are less than 0.05, suggesting that the data do not follow a normal distribution. Although in dimension 2 of the pre-test they obtained a higher value in the Shapiro–Wilk test, the result still indicates non-normality.

Since the normality tests reflected a significant deviation, non-parametric tests were performed in the inferential analyses. This ensured a more concrete and robust statistical analysis by achieving a greater comparison between the pre-test and post-test.

3.3. Descriptive Analysis of the Data

Table 4 below shows the descriptive means of each of the items included in the evaluation instrument, both pre-test and post-test, as well as the data obtained on variance, kurtosis, and skewness.

In general, we observe an increase in the means obtained in each of the items after the intervention of the UDL and the technologies, thus suggesting an improvement in the scores of the dimensions studied. In fact, if we look at each of the dimensions, for example, in the R dimension (items R1–R7), the range of means oscillated between 5.26 and 5.51 in the pre-test, whereas in the post-test they were between 5.44 and 5.70, presenting in the same way a decrease in the standard deviation and suggesting a greater concentration of responses in the higher values of the Likert scale.

Table 4. Descriptive data analysis.

	Pre-Test					Post-Test				
	Mean	Standard Deviation	Variance	Skewness	Kurtosis	Mean	Standard Deviation	Variance	Skewness	Kurtosis
	Statistical	Statistical	Statistical	Statistical	Statistical	Statistical	Statistical	Statistical	Statistical	Statistical
R1	5.26	0.926	0.857	−1.602	3.459	5.44	0.723	0.523	−1.230	1.424
R2	5.37	0.909	0.827	−2.161	6.732	5.48	0.777	0.604	−1.677	3.102
R3	5.52	0.898	0.806	−2.598	8.321	5.62	0.685	0.469	−2.237	6.013
R4	5.41	0.947	0.896	−2.055	5.022	5.56	0.788	0.621	−2.224	5.863
R5	5.38	0.966	0.933	−2.130	5.718	5.58	0.692	0.479	−1.903	5.303
R6	5.51	0.841	0.708	−2.647	9.851	5.67	0.632	0.399	−2.396	7.514
R7	5.51	0.968	0.936	−2.658	7.818	5.70	0.591	0.349	−2.699	11.780
AE1	3.87	1.336	1.784	−0.128	−0.713	5.00	1.036	1.073	−1.066	0.939
AE2	3.83	1.119	1.252	−0.201	0.009	4.77	1.033	1.068	−0.458	−0.532
AE3	4.03	1.175	1.381	−0.292	−0.223	4.93	1.059	1.122	−0.804	−0.102
AE4	3.15	1.362	1.854	0.143	−0.714	4.44	1.378	1.898	−0.607	−0.390
AE5	3.71	1.376	1.894	−0.127	−0.659	4.88	1.137	1.294	−0.670	−0.479
E1	5.04	0.990	0.980	−0.783	−0.166	5.31	0.895	0.801	−1.040	−0.005
E2	5.28	0.892	0.795	−1.248	1.260	5.44	0.761	0.580	−1.296	1.133
E3	4.99	1.006	1.013	−0.824	0.197	5.42	0.786	0.618	−1.305	1.496
E4	5.22	0.916	0.839	−1.007	0.371	5.37	0.900	0.810	−1.658	3.031

In the AE dimension (items AE1–AE5), a better score was also observed after the post-test compared to the pre-test. In fact, although it was the dimension that obtained lower values, it went from a range of 3.15 and 4.03 in the pre-test to values between 4.44 and 5.00 in the post-test. This increase was reflected in an overall reduction in variance, thus indicating a greater homogeneity in the responses of the university students.

Furthermore, in dimension E (items E1–E4), they showed a very similar pattern to the AE dimension, as their measurement ranges oscillated steadily and with a slight decrease in the dispersion of the data. In the pre-test they ranged between 4.99 and 5.28, while in the post-test the range was between 5.31 and 5.44.

Following on from these aspects, and focusing on skewness, it is observed that most of the items obtained negative values in both the pre-test and post-test, thus suggesting that the responses were more concentrated on the higher values of the scale provided. This trend is further reflected in the post-test, which is consistent with the general increase after the intervention. In fact, item R7 went from a skewness of −2.658 in the pre-test to −2.699 in the post-test, thus reflecting a greater accumulation of responses in higher values.

In relation to kurtosis, it is observed that in the post-test several items increased, especially those in the R dimension. This indicates that there is greater leptokurtosis after the intervention. In other words, there is a greater concentration of values near the mean and with more elongated tails. Taking the previous item, R7, as a reference, we observe that in the pre-test it obtained a value of 7.818 and in the post-test it obtained a value of 11.780. This increase points to a reduction in the variability of the responses, which is interpreted as greater consistency in the perception of the university students after the intervention with the UDL and ICT.

Finally, Table 5 shows the weighted means of the dimensions studied in the pre-test and post-test. Each of the dimensions significantly improved, respectively, in the post-test.

In addition, the R dimension scored higher than the other two, followed by the E dimension. However, the AE dimension scored the lowest in the post-test but improved significantly after the educational intervention in UDL and ICT among university students.

Table 5. Overall average for each dimension.

Statistics for S Sample				
		Mean	**Standard Deviation**	**Mean Standard Error**
Pre-test	Dimension R	5.4219	0.73658	0.03749
	Dimension AE	3.7192	0.90763	0.04620
	Dimension E	5.1328	0.67710	0.03446
Post-test	Dimension R	5.5799	0.54228	0.02760
	Dimension AE	4.8005	0.93147	0.04741
	Dimension E	5.3847	0.62131	0.03162

3.4. Hypothesis Testing Using the Wilcoxon Test

In order to fulfil the pre-established objective, the main hypothesis of the study was tested. For this purpose, the Wilcoxon signed-rank test was applied for related samples, due to the fact that the data obtained did not comply with the standards of normality and the quasi-experimental pre-test and post-test design.

The results obtained rejected H0 and accepted H1 in all the dimensions of the study carried out. In the R dimension, a significant difference was obtained between pre-test and post-test of Z = 2.523 and with a significance level of $p = 0.012$. These data suggested a significant improvement in the way university students perceived greater representation after the SAD and ICT intervention (see Table 6).

Table 6. Summary of hypothesis testing.

Null Hypothesis	Test	Sig [a,b]	Decision
The median difference between Pre-test dimension R and Post-test dimension R is equal to 0	Wilcoxon signed-rank test for related samples	0.012	Reject the null hypothesis
The median difference between Pre-test dimension AE and Post-test dimension AE is equal to 0	Wilcoxon signed-rank test for related samples	<0.001	Reject the null hypothesis
The median difference between Pre-test dimension E and Post-test dimension E is equal to 0	Wilcoxon signed-rank test for related samples	<0.001	Reject the null hypothesis

[a] The significance level is 0.050. [b] The asymptotic significance is shown.

The same is true for the AE dimension, where the difference was highly significant. The Z-value was 12.471 and the p-value was less than 0.001, thus suggesting a strong and robust impact on the intervention for multiple forms of action and expression through the UDL and ICT approach. Similarly, in dimension C, a significant difference was obtained with a Z-value of 4.876 and p-value of less than 0.001, reflecting an increase in the degree of involvement in multiple forms of engagement in the use of technological resources (see Table 7).

Table 7. Summary of Wilcoxon signed-rank test for related samples.

	R Dimension	AE Dimension	E Dimension
Test statistic	29,135.500	55,708.500	33,532.000
Standard error	1622.249	1933.597	1643.317
Standardized test statistic (Z)	2.523	12.471	4.876
Asymptotic sig. (Bilateral test)	0.012	<0.001	<0.001

These findings support the acceptance of H1 and the rejection of H, thus suggesting that the implementation of UDL in combination with the use of ICT improves the ways of representing information with technologies, promotes their learning more effectively, and increases the commitment towards the use of technology, reflecting a satisfactory increase after the joint integration, thanks to the positive effect that the intervention has had among the key variables of the study.

4. Discussion

The results obtained allow us to confirm the alternative hypothesis (H1), empirically validating that the implementation of Universal Design for Learning (UDL) in combination with technologies has a significant and positive impact on the teaching–learning processes of university students in training. The three dimensions evaluated—multiple forms of representation, action/expression, and engagement—showed statistically significant improvement after the intervention, which is evidence of the transformative potential of this methodological synergy.

UDL is consolidated as a curricular model oriented towards attention to diversity from an inclusive and innovative perspective [3,6]. The improvement recorded in the representation dimension corroborates the effectiveness of the use of digital resources to diversify the ways in which information is presented, favouring accessibility and an understanding of the content [7]. The particularly positive responses from students reflect a high appreciation of digital resources as a means of diversifying the presentation of content and facilitating understanding. By offering multiple representation formats (enriched texts, visual, sound and interactive elements, virtuality, etc.), technologies make it possible to better adapt to different learning styles, in line with VAK sensory theory and the proposals of other authors. VAK sensory theory is a model of learning styles that classifies students' preferences into three main categories: Visual, Auditory, and Kinesthetic. This theory holds that each person has a predominant way of receiving and processing information, which can influence how they learn most effectively [28,29].

Similarly, and along the same lines as the results in the dimension of action and expression, the results confirm that the use of technologies enables multiple ways for students to demonstrate their learning. Significant progress was observed in their responses, despite the fact that this was the dimension with the greatest dispersion, which reflects the need to strengthen students' pedagogical appropriation of technologies as expressive and evaluative tools [30].

In the engagement dimension, significant improvements were also found, proving the importance of technologies as mediators of motivation, allowing the implementation of adaptive, gamified, and personalised strategies that increase the involvement ('engagement') of students in their learning process [8,21]. This confirms the potential of technology as a catalyst for student motivation and interest [21,27]. In this line, the implementation of interactive technologies such as simulators, collaborative murals, or gamified resources is shown to be an effective way to boost participation and promote the active involvement of students [31,32].

The results obtained in this study ratify the relevance of integrating UDL with ICT as a pedagogical strategy for the attention to diversity and the improvement of teaching–learning processes in higher education. The significant improvement observed between pre-test and post-test scores in the three dimensions of UDL (representation, action and expression, and engagement) empirically validates the positive impact of this methodology, which coincides with research [6,25] that highlights the effectiveness of UDL in fostering inclusive, motivating, and adaptive environments.

Recently, authors [33] confirm how the convergence of UDL with Artificial Intelligence (AI) promotes autonomous learning on the part of students, as active subjects and protagonists, and by integrating UDL and AI barriers and obstacles are eliminated, fostering inclusive educational spaces. Authors [10] highlight improvements in student learning outcomes with the use of technologies such as AI, gamification, and robotics. For their part [11], students in higher education perceive technologies as facilitators of UDL and point out that, although teachers are usually aware of the principles of UDL, there is a disconnect between theoretical understanding and practical application. The need for more comprehensive professional development programmes is highlighted. This study reflects the challenges related to the need for training in digital skills for teachers and the meaning of inclusive, diverse, and equitable education.

5. Conclusions

The data confirm that the implementation of the UDL, supported by digital technologies, incorporated into the training of future teachers during several sessions in which they can practice and work on its three dimensions, significantly improves the level of knowledge of the teachers after the post-test. This combination makes it possible to address the diversity of students from a logic that is not compensatory but transformative and integrative [25,33]. This is why we affirm that educational intervention based on the UDL approach and the use of technologies produces significant changes in students' perceptions once they have worked with them. It is shown that this combination not only favours the comprehension and representation of information but also optimises the students' forms of expression and enhances their commitment to learning.

The representation dimension was the most highly rated by the students, which underlines the value they have placed on diversifying the formats of content presentation through accessible and adaptive technological tools. This is in line with studies highlighting the role of technologies in improving students' reading, visual, and listening comprehension [6,28].

The variability of resources used in the dimension of action and expression is evidence of a gap in the pedagogical appropriation of technologies that they have been able to overcome. We believe that this aspect should be addressed through training proposals that enable future teachers to integrate digital resources as instruments for content production and assertive communication, as well as for formative assessment [23,30].

Finally, in the dimension of commitment, it should be noted that the possibility of personalising the educational experience has reinforced students' intrinsic motivation, a central element for academic success [21,27], as evidenced by the positive scores obtained in this dimension in the post-test.

This research confirms the urgency to include work with the UDL model and technologies in different subjects and in a cross-cutting manner, thereby enabling the development of cross-cutting competences that are fundamental for their training and in line with an inclusive and quality education. It also offers a replicable framework for future research at other educational levels and in other cultural contexts.

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Institutional Review Board Statement: In accordance with our institution's Policies (https://www.investigacion.us.es/apoyo-al-investigador/comites-de-etica/comite-de-etica-de-investigacion-de-la-universidad-de-sevilla-ceius (accessed on 29 May 2025)), research activities conducted in educational settings for pedagogical purposes that do not involve sensitive or identifiable personal data are exempt from prior review or approval by an ethics committee.

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