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DE LOS FINES Y PROPÓSITOS DE EDUWEB, REVISTA DE TECNOLOGÍA DE INFORMACIÓN Y COMUNICACIÓN EN EDUCACIÓN

Eduweb, la revista de Tecnología de Información y Comunicación en Educación, es una publicación de carácter nacional e internacional de divulgación del conocimiento, del uso, aplicación y experiencias de las Tecnologías de la Información y Comunicación (TIC) en ambientes educativos. Con la revista se pretende divulgar las innovaciones que en materia de TIC están siendo implementadas y ensayadas en los diferentes niveles y modalidades del sistema educativo venezolano e iberoamericano. De igual manera contribuir a proyectar las experiencias de estudiantes de pre y postgrado, docentes, investigadores y especialistas en TIC en educación en la Universidad de Carabobo y en otras universidades de Venezuela y de otros países de Iberoamérica. Es una revista arbitrada e indexada adscrita al programa de la especialización en Tecnología de la Computación en Educación, de la Facultad de Ciencias de la Educación de la Universidad de Carabobo, registrada bajo el ISSN 1856-7576. Editada en formato impreso y digital.

Visión

Ser un espacio académico-científico de difusión y divulgación de las distintas tendencias del pensamiento universal ubicadas en el área de TIC en ambientes educativos, con altos niveles de calidad académica.

Misión

Promover y facilitar la difusión y divulgación de los productos de las investigaciones y experiencias de los docentes e investigadores de la Universidad de Carabobo y otras universidades del país y del mundo en el área de TIC en ambientes educativos; motivar la participación en redes comunes de información y publicación nacional e internacional; coordinar esfuerzos y velar por la calidad de las publicaciones a fin de procurar elevar el nivel académico del personal docente y de investigación mediante el desarrollo de trabajos de investigación como función esencial en su crecimiento académico.

Objetivos

Servir como órgano de divulgación de las TIC y su influencia en ambientes educativos. Estimular la producción intelectual no solo en los docentes e investigadores de la Universidad de Carabobo, sino también en otros centros de educación e investigación nacional e internacional.

Propiciar el intercambio cultural, académico, científico y tecnológico con otros centros de educación superior en Venezuela y el mundo.

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Original Article

Editorial

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El inicio de un nuevo año siempre convoca a una reflexión profunda sobre el rumbo que toma la educación en un mundo marcado por la aceleración tecnológica. Cada ciclo que comienza nos recuerda que la universidad es un espacio vivo donde se ensayan nuevas formas de comprender la realidad, de construir conocimiento y de imaginar futuros posibles. En este 2026, esa tarea adquiere una intensidad particular: la tecnología digital y la inteligencia artificial se han convertido en fuerzas estructurales que redefinen la experiencia educativa, los modos de investigar y las prácticas profesionales. Este primer número de la *Revista Eduweb* nace en ese horizonte de transformación, donde la educación se piensa a sí misma desde la complejidad del presente y desde la responsabilidad de anticipar lo que viene.

La comunidad investigadora ha mostrado un interés creciente por examinar, con rigor y sensibilidad crítica, el impacto de estas tecnologías en la formación universitaria. No es casual que tantos autores hayan elegido este espacio editorial para compartir sus hallazgos: la educación vive un momento de inflexión histórica, y la investigación se vuelve una brújula indispensable para comprenderlo. La tecnología es un recurso que moldea la manera en que aprendemos, enseñamos y producimos conocimiento. La inteligencia artificial, en particular, irrumpe como un fenómeno que interpela las metodologías y las concepciones filosóficas sobre la creatividad, la autoría, la autonomía y la naturaleza misma del saber.

La presencia de lo digital en la educación superior no se limita a la incorporación de herramientas; implica una redefinición profunda de las prácticas académicas. La universidad contemporánea se ha convertido en un ecosistema híbrido donde convergen plataformas, algoritmos, entornos virtuales, lenguajes multimodales y nuevas formas de interacción humana. Este número recoge investigaciones que, desde distintas perspectivas, muestran cómo la tecnología redefine la formación profesional, la ciudadanía digital, la inclusión educativa, la investigación académica y la gestión institucional. La diversidad de enfoques revela que la transformación digital se despliega en múltiples capas, desde la alfabetización digital hasta la innovación pedagógica, desde la autoeficacia estudiantil hasta la ética de la IA.

La irrupción de la inteligencia artificial generativa marca un antes y un después en la vida universitaria. Su capacidad para producir textos, imágenes, análisis y simulaciones abre posibilidades inéditas, pero también plantea preguntas profundas sobre la naturaleza del aprendizaje y la investigación. La IA obliga a repensar la relación entre el sujeto y el conocimiento: ¿Qué significa aprender cuando los sistemas pueden generar respuestas? ¿Cómo se redefine la creatividad cuando la producción intelectual se vuelve colaborativa entre humanos y máquinas? ¿Qué nuevas competencias deben desarrollarse para habitar críticamente

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este entorno? Las investigaciones reunidas en este volumen abordan estas cuestiones desde perspectivas comparativas, pedagógicas, metodológicas y filosóficas, mostrando que la IA es solo una herramienta y un acontecimiento epistemológico.

En medio de esta transformación, la educación sigue siendo un proyecto profundamente humano. La tecnología amplía nuestras capacidades, pero también nos invita a reflexionar sobre aquello que no puede automatizarse: la empatía, la sensibilidad estética, la deliberación ética, la construcción de comunidad. Las investigaciones incluidas en este número recuerdan que la educación digital no puede reducirse a eficiencia o innovación técnica; debe orientarse hacia la formación integral, hacia la construcción de sujetos capaces de pensar críticamente, de convivir en la diversidad y de actuar con responsabilidad en un mundo interconectado.

Cada artículo de este volumen es una pieza en el mosaico de la transformación educativa contemporánea. Invitamos a nuestros lectores a recorrer estas páginas con una mirada abierta y reflexiva, a extraer de cada estudio los aportes y hallazgos que puedan nutrir su práctica profesional y su pensamiento crítico. La riqueza de este número radica en su capacidad para mostrar que la tecnología y la inteligencia artificial son medios para expandir las posibilidades del conocimiento y para fortalecer la misión formativa de la educación superior.

Lean entre líneas y en cada línea, como quien se adentra en un territorio donde la palabra no solo informa, sino que revela, sugiere y convoca. Permitan que estas páginas los acompañen como los libros acompañaron a Don Quijote: para despertar la imaginación crítica, para descubrir horizontes allí donde otros solo ven superficie. Cada investigación aquí reunida es una invitación a detenerse, a interpretar con atención y a dejarse transformar por ese diálogo silencioso que solo la lectura profunda permite. Que este número sea, para cada lector, un espacio donde el pensamiento se expanda y donde la educación, en su encuentro con la tecnología y la inteligencia artificial, siga siendo una aventura intelectual capaz de renovar nuestra manera de comprender el mundo.

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Original Article

Digitally oriented strategies for developing professional competence of future foreign language specialists

Estrategias orientadas digitalmente para el desarrollo de la competencia profesional de futuros especialistas en lenguas extranjeras

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Abstract

This study aims to substantiate and experimentally verify the effectiveness of digitally oriented pedagogical technology for developing professional competence among undergraduate students majoring in foreign languages. A quasi-experimental mixed-methods research design was employed, involving control (n = 77) and experimental (n = 79) groups. The pedagogical intervention integrated digital learning platforms, language learning applications, artificial intelligence–based tools, digital portfolios, and gamified learning activities into the instructional process. Data were collected through questionnaires, diagnostic tests, structured observations, and self-assessment scales, covering motivational, cognitive, epistemological, activity-based, and communicative components of professional competence. Quantitative data were analyzed using Pearson's chi-square test (χ^2) at a significance level of $\alpha = 0.05$. The findings reveal statistically significant improvements in the overall level of professional competence and its individual components in the experimental group compared to the control group. The results confirm that the implementation of digitally oriented pedagogical technology contributes to higher levels of student motivation, professional knowledge acquisition, communicative skills, and practical language use. The study provides empirical evidence supporting the effectiveness of digital technologies in foreign language teacher education and offers practical implications for modernizing professional training in higher education institutions.

Keywords: professional competence, foreign language specialists, digital technologies, digital educational environment, higher education.

Resumen

El presente estudio tiene como objetivo fundamentar y verificar experimentalmente la eficacia de una tecnología pedagógica orientada digitalmente para el desarrollo de la competencia profesional en estudiantes universitarios de especialidades filológicas. Se empleó un diseño de investigación cuasi experimental de métodos mixtos, que incluyó un grupo de control (n = 77) y un grupo experimental (n = 79). La intervención pedagógica integró plataformas de aprendizaje digital, aplicaciones para el aprendizaje de lenguas, herramientas basadas en inteligencia artificial, portafolios digitales y actividades de aprendizaje gamificadas en el proceso educativo. La recolección de datos se realizó mediante cuestionarios, pruebas diagnósticas, observaciones estructuradas y escalas de autoevaluación, abarcando los componentes motivacional, cognitivo, epistemológico, procedimental y comunicativo de la competencia profesional. Los datos cuantitativos se analizaron mediante la prueba de chi-cuadrado de Pearson (χ^2) con un nivel de significación de $\alpha = 0,05$. Los resultados evidencian mejoras estadísticamente significativas en el nivel general de la competencia profesional y en sus

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componentes individuales en el grupo experimental en comparación con el grupo de control. Los hallazgos confirman que la implementación de tecnologías pedagógicas orientadas digitalmente contribuye al incremento de la motivación estudiantil, la adquisición de conocimientos profesionales, el desarrollo de habilidades comunicativas y el uso práctico de la lengua extranjera. El estudio aporta evidencia empírica sobre la eficacia de las tecnologías digitales en la formación de especialistas en lenguas extranjeras y ofrece implicaciones prácticas para la modernización de la educación superior.

Palabras clave: competencia profesional, especialistas en lenguas extranjeras, tecnologías digitales, entorno educativo digital, educación superior.

Introduction

The modernization of the education system worldwide is a major trend, accompanied by significant changes in the practical and theoretical approaches to the educational process in higher education. Over time, the tasks and goals of language training for specialists in the higher education system have changed, reflecting cultural and political trends in society's development. With an emphasis on expanding the language competence of higher education students, we can state that today, a change in the educational paradigm is becoming one of the key professional competencies that determine the readiness of specialists for successful professional interaction in the academic, international, and scientific space (Moisés & Borges, 2021).

The issue of creating innovative learning tools in the context of the informatization of education, aimed at organizing work in a single information and educational space for education seekers to improve the quality of education, is becoming increasingly relevant. Digital educational resources are learning tools; they are information sources containing text, graphics, video, photos, and other content, aimed at implementing the tasks and goals of modern education and presented in digital form. Multifunctional digital technologies provide the opportunity for quick access and search for necessary information sources, placement of a larger amount of information, high-quality and objective testing of students' knowledge, diverse use of graphic design, visual representation of complex processes and phenomena, simultaneous receipt of information, which is presented in various forms for future specialists in a foreign language: audio, visual, etc. Therefore, practical solutions to the tasks of forming professional competence of a person using digital technologies, and the informatization of the entire educational environment require improving the training of future specialists in a foreign language using digital technologies, mastering the methodology of designing the educational process based on the use of digital educational resources (Corbella & Marcos, 2020).

Modern society is called an information society because people process and receive a large flow of information every day. The new generation is significantly different from previous generations in its need to use digital technologies in its own work, its adaptation to constantly changing living conditions, and its increasingly frequent use of digital technologies. Using information technology and digital media was not widespread across all areas of work ten years ago. However, in the modern economic situation, these competencies are the primary skills of future specialists necessary for the successful formation of a modern person's career. Today, people know how to watch something online, use IT skills, and write emails. Within the framework of digitalization, attention should be paid to the development of professional competence of future specialists in a foreign language using digital technologies from the very beginning of the educational process. In the context of

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the study, the opportunities provided by modern digital technologies are significant for language learning. Interest in this area of methodology is growing, becoming an integral part of the professional training of a modern specialist in a foreign language. The use of digital technologies in teaching foreign languages opens new opportunities for students and teachers in their own research. It enables them to undertake innovative tasks in the teaching and learning of a foreign language. Due to the widespread use of new digital technologies at the current stage of foreign language teaching, there is a need to review the ways and strategies for implementing the process of forming professional competence of future foreign language specialists using digital technologies, taking into account the trends in improving and modernizing education in the 21st century. In the context of profound socio-cultural and economic changes in the digital era, the relevance of the above is determined by the need for students to express themselves and define themselves, rather than solely by the social order (Orgado & Durão, 2022).

Thus, radical changes in the methods for developing the professional competence of future specialists in a foreign language using digital technologies give rise to new priorities in their training. This concerns the ability to operate with basic settings, mastering Internet resources, their digital component, experience in using innovative technologies, receiving, processing, memorizing professional information, finding the necessary information, forming knowledge on its basis, being able to select professional material using ICT, acquiring the skills necessary for the future profession to use digital technologies to work with professional materials.

Today, higher education is faced with the task of forming the professional competence of future specialists and professionals using digital technologies, and promoting students' awareness of their responsibility for searching, identifying, and placing their own information in the boundless space of Internet resources.

Literature Review

Recently, technological advances have influenced language teaching and learning. Within the framework of digitalization, Schaefer et al. (2019) examined the development of professional competence among future foreign language specialists using digital technologies at the stage of the educational process. The authors showed the impact of digital technologies, which enabled different applicants in the educational space to experience the effectiveness of the learning process through innovative resources, namely digital stories and digital games, web conferencing, and telecollaboration. The study shows how these digital resources can contribute to L2 learning development.

In the context of the study, Galante et al. (2023) highlight the significant opportunities for language learning that modern digital technologies provide. Interest in this area of methodology is growing, becoming an integral part of the professional training of a modern foreign language specialist. The authors have demonstrated the benefits of multilingual pedagogy for students' language learning experience and conducted the necessary additional research to identify the most effective pedagogical methods to implement in a digital environment in foreign language learning programs. The authors describe the case studies conducted with students and teachers in Brazil in French, English, and Spanish. The researchers implemented five plurilingual strategies in language courses: pluriliteracy, translingualism, intercultural comparisons, interlingual comparisons, and translation for mediation.

In modern society, the need for personality development through increasing globalization is the study of a second language in a multicultural environment.

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Harvey Arce & Cuadros Valdivia (2020) proposed innovative teaching methods for modern students, who are called digital media, and must adapt to the digital era of knowledge and educational technologies. Scientists have developed a digital resource for learning foreign languages that incorporates gamification and competition to attract students to the course and motivate them. Using a virtual environment, ways to improve the processing of the received theoretical information are shown, including elements of competitive activity and gamification, such as a user progress indicator, receiving medals for completing tasks, and a rating according to the points obtained, to motivate students and improve learning when learning a second language using the author's methodology.

The study by Jacome Paredes et al. (2025) examines the use of artificial intelligence-based digital tools for vocabulary memorization. It focuses on students enrolled in a program in which English is taught as a foreign language within the Linguistic and Pedagogical Program of Pedagogy of Foreign and National Languages (PINE) at the Southern State University of Manabí (UNESUM), Ecuador. The study used tools such as ChatGPT, augmented reality, and intelligent tutoring systems. The role of multimedia resources in vocabulary learning is proven. The importance of a digital adaptive environment is proven. Optimized interfaces are recommended for better student learning.

In Digital Language Education in the Context of Modern Trends, Pikhart et al. (2023) assessed the effectiveness of innovative tools from different perspectives of applied linguistics and psycholinguistics. The authors evaluated L2 vocabulary retention (as opposed to digital media) when using printed text. The study's results clearly show that students with access to printed vocabulary can better remember second-language vocabulary, write translations in their native language, and highlight fragments.

The aim of the study by Cabrera-Solano (2020), conducted at the Technical University of Loja, in southern Ecuador, is to analyze the use of digital portfolios (English as a Foreign Language) to improve EFL speaking skills in undergraduate English students. In this study, a mixed-methods approach was used to collect and analyze data, including observation sheets, pre- and post-questionnaires, and conversational rubrics. To create digital portfolios, students used their smartphones to access Google Drive, which contained videos and audio on the specific topics covered in the course. By analyzing students' oral speech, personalized feedback was provided through speech artifacts uploaded to each portfolio. The study's results demonstrated the effectiveness of digital portfolios in improving students' fluency and pronunciation.

The use of digital portfolios to improve EFL writing skills was demonstrated in a study of English as a foreign language (EFL) students enrolled in an English language course at a private university in southern Ecuador. Students used laptops and smartphones to create digital portfolios in Google Drive, including collaborative photos, reflective essays, and infographics on academic topics aligned with the course competencies. Digital portfolios are an effective learning tool that improves EFL students' writing skills and motivates them to reflect on their own progress.

Campo Paredes & Duarte Varela (2025) analyzed Brazilian students' perceptions of the use of Tandem and Duolingo in Spanish as a foreign language. The study's results show that students positively evaluate these digital applications as supporting tools for consistent practice and vocabulary expansion. The teacher's role is emphasized as a guide and intercultural mediator in the learning process. The

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authors conclude that the teacher plays an essential role in foreign language learning, that modern applications complement the learning process, and that digital literacy is necessary.

The purpose of the article is to substantiate and experimentally verify the effectiveness of digitally oriented pedagogical technology for the formation of professional competence of future foreign language specialists.

Methodology

Research Design

The study employed a **quasi-experimental mixed-methods design** combining quantitative and qualitative approaches. This design was chosen to comprehensively examine the effectiveness of digitally oriented pedagogical technology in developing the professional competence of future foreign language specialists.

The experimental design included **control (CG) and experimental groups (EG)** with pre-test and post-test measurements, enabling comparison of learning outcomes and assessment of statistically significant differences resulting from the intervention.

Participants

The empirical study was conducted between **2022 and 2024** in higher education institutions in Ukraine. The total sample consisted of **156 undergraduate students majoring in foreign languages**, who were randomly assigned to:

- Experimental group (EG): 79 participants
- Control group (CG): 77 participants

The groups were independent and comparable in terms of age, academic background, and initial level of professional competence, which was confirmed at the ascertaining stage. The sample size met methodological requirements for ensuring statistical reliability and generalizability of results.

Pedagogical Intervention

The experimental group was taught using a **digitally oriented pedagogical technology**, while the control group followed traditional instructional methods.

The pedagogical technology was based on the following methodological approaches: competence-based, student-centered, systemic, axiological, practice-oriented.

The intervention included: integration of digital learning platforms (Moodle, Google Classroom, LearningApps); use of language learning applications (Duolingo, Memrise, Babbel); application of AI-based tools (e.g., ChatGPT) for interactive language practice; digital portfolios and project-based tasks; gamification and online collaboration tools.

The instructional process was implemented consistently across all stages of the educational cycle in the experimental group.

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Instruments and Data Collection

To assess the formation of professional competence, a **multicomponent diagnostic framework** was applied, comprising the following components: motivational, cognitive, epistemological, activity-based, communicative.

Data collection instruments included: structured questionnaires, diagnostic tests, observation protocols, self-assessment scales.

Measurements were conducted at two stages:

1. **Ascertaining stage (pre-test)** – to determine the initial level of professional competence.
2. **Formative stage (post-test)** – to evaluate changes resulting from the pedagogical intervention.

Data Analysis

Quantitative data were analyzed using **methods of mathematical statistics**. To test the research hypotheses, the **Pearson's chi-square (χ^2) test** was applied at a significance level of **$\alpha = 0.05$**.

Two statistical hypotheses were formulated:

- **H_0 (null hypothesis):** there are no statistically significant differences between the experimental and control groups.
- **H_1 (alternative hypothesis):** there are statistically significant differences between the groups.

The empirical χ^2 values were compared with critical values to determine the acceptance or rejection of hypotheses. Statistical processing ensured a **95% confidence level**, confirming the reliability and validity of the findings.

Qualitative data were used to interpret quantitative results and provide additional insights into the learning process and students' engagement with digital technologies.

Ethical Considerations

Participation in the study was voluntary. All participants were informed about the research objectives, procedures, and confidentiality of their data. Ethical principles of educational research were strictly observed.

Results and Discussion

The content of the digital environment for the formation of professional competence of future specialists in a foreign language.

The use of digital technologies in language classes contributes to the development of professional competence among future specialists in a foreign language. It forms the worldview of communicative verbal activity in three aspects:

- Communication of students through the use of network technologies in real time.

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- Interactive dialogic interaction with the student's computer – and as a result, the implementation of human-machine dialogue.
- Interaction of students with educational digital programs. Teaching various types of language activities: listening, speaking, reading, and writing are the main components of the content of foreign language teaching (Molina Guillén et al., 2025).

Educational computer programs, which are also simulators, help students independently build their knowledge, contribute to the development of professional competence among future specialists in a foreign language, and facilitate the organization of students' independent work (Nobrega & Rozenfeld, 2019).

The creation of a practice-oriented digital educational environment is an important condition for the formation of professional competence of future specialists (involving students in the use and development of modern web resources, web technologies, and software tools in the process of studying at the university), such as:

- Internet resource: MOZAIK Education (interactive software for teachers, featuring virtual laboratories and programs).
- Google Classroom (a platform created for online learning, using graphic and text information, video, etc.).
- Edmodo is a web application (similar to a social network) used to facilitate effective student interaction.
- Moodle (an innovative open system for managing distance education) uses innovative tools to ensure the educational process.
- LearningApps.org (an online service created to provide interactive tasks, create various exercises, etc.).
- Zoom (a service created for the purpose of conducting online meetings and video conferences) (Rodríguez-Vizzuett et al., 2019).

Significant in the formation of professional competence of future foreign language specialists is the Internet portfolio – a technology that serves as an important tool for the teacher, integrates the capabilities of information and pedagogical technologies, and determines the degree of readiness of the specialist for professional activity in the conditions of digital requirements (Rocha & da Silva, 2020).

Let us consider the most common computer programs that should be used in the formation of professional competence of future foreign language specialists. Memrise, Duolingo, and Babbel offer interactive exercises, vocabulary trainers, and grammar tasks for language learning. They are ideal for different levels of language learning, for repeating vocabulary or grammar, and for practicing the language at any time and anywhere. These programs help develop speaking, listening, and reading skills through tasks and interactive exercises that adapt to learners' levels. Babbel and Memrise provide context and create real situations that allow you to use expressions and phrases in communication. Duolingo uses a system of achievements and points, which motivates higher education students to continue their studies. These programs allow students to significantly improve their language proficiency, providing a comprehensive approach to language learning. Tasks using the Duolingo application "Language Journey Blog" are practical. Its purpose is reflection and self-assessment, improving language skills, and motivating students to study further. Duolingo tools should be used to learn grammar and new vocabulary; iMovie, YouTube, Adobe Spark, or a phone camera are valuable tools for editing and recording videos (Acosta Padrón et al., 2022).

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Chatbots and artificial intelligence. GPT-based bots, such as ChatGPT, offer a dialogue mode and help develop communication skills. Artificial intelligence can correct errors, maintain a conversation on various topics, generate tasks, and explain rules. Artificial intelligence services analyze a student's knowledge level and recommend personalized exercises based on problem areas and progress (Casimiro Perlaza & Vega Rosas, 2025).

Online language learning platforms. Online language learning platforms offer English courses from Udemy, Coursera, and edX, which include tests, video lessons, and exercises. The courses are highly specialized (e.g., technical English, business English), which helps students choose topics that interest them. Zoom and other video conferencing services play an important role, allowing for online classes in groups or with teachers (Cristancho Triana & Corredor Aponte, 2023).

Gaming platforms and gamification. Gamification makes learning more fun through the following platforms: Kahoot!, Quizlet. Applicants to the educational space can compete in quizzes and play games, which help consolidate the material already studied in an interesting and easy way (Llanes Sánchez et al., 2022).

Social networks and communities. Popular platforms are Reddit, Instagram, and Facebook, where you can follow pages with educational content or join groups for studying a foreign language. This promotes live speech, vocabulary, and trends relevant to everyday communication. Students have the opportunity to follow bloggers and English-speaking accounts, communicate in communities, and connect with native speakers on online forums and with those who are studying a foreign language to get support and practice, learn about different cultures, and increase their vocabulary (Lunevich, 2021).

Organization and course of the experimental study

The purpose of the experimental work was to verify the effectiveness of the developed pedagogical technology and pedagogical conditions for the formation of professional competence of future foreign language specialists using digital technologies.

The experimental work consisted of the following stages:

The search stage provided justification for the study's relevance, defined the research problem, analyzed literary sources and scientific research, and examined the use of educational digital technologies.

The conceptual stage included defining the research apparatus, formulating the goal, justifying the pedagogical technology, and specifying the pedagogical conditions for the development of professional competence among future foreign language specialists using digital technologies.

The prognostic stage provided for the development of the experimental methodology, the selection of methods and means of diagnostics, and the assessment of the formation of the components of professional competence of future foreign language specialists using digital technologies, as well as the processing and collection of empirical data.

The organizational stage allowed determining the sample volume and the general sets of the studied elements, and forming the experimental and control groups.

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The technological stage involved conducting a pedagogical experiment, which included the formative and ascertaining stages.

At **the ascertaining stage**, the initial level of professional competence in a foreign language for future specialists was established. Using mathematical statistics methods, the data obtained were processed to verify the absence or presence of differences (statistically significant) between the experimental and control groups.

In the experimental group, during the **formative stage** of the study, pedagogical technology and pedagogical conditions for developing the professional competence of future specialists in a foreign language using digital technologies were introduced. During 2022-2024, the educational process in the experimental group was organized using the selected stages. In the control and experimental groups, a final and ongoing assessment and diagnosis of the development of professional competence in a foreign language among future specialists were systematically carried out.

The stage of implementing the generalized results of the experimental work enabled us to analyze the practical outcomes and formulate conclusions regarding the goal of the experimental work.

During the experiment, to diagnose the development of professional competence in a foreign language according to specific components, indicators, and levels, diagnostic techniques and empirical methods were used.

A hypothesis was formulated: the introduction of developed pedagogical conditions into the professional training process of future specialists in a foreign language increases the effectiveness of the formation of professional competence in these specialists.

In the control and experimental groups, the number of respondents should be at least 69 people to ensure the reliability of the experiment.

Within the sample population (156 participants in the experiment), a control group (77 respondents) and an experimental group (79 respondents) were selected, and the groups were independent. According to the results of the survey of the sample, it is necessary to compare the formation of professional competence of future specialists in a foreign language among students and formulate conclusions about the probability, existing differences, the influence of pedagogical technology and pedagogical conditions of the formation of professional competence of future specialists in a foreign language using digital technologies, the possibility of extending the obtained effect to the general population of respondents.

To analyze the data obtained in the empirical study, we introduced a method of testing statistical hypotheses, in particular, two statistical hypotheses:

- **Null hypothesis H_0** − hypothesis about the absence of differences between the experimental group and the control group.
- **Alternative hypothesis H_1** − hypothesis about the significance of differences between the experimental and control groups.

Let us reveal the methodology for testing hypotheses: based on the EG and CG indicators (data on the results of observations), the empirical value (χ^2_{emp}) of the criterion was calculated, which was compared with the critical (χ^2_{crit}) value of the criterion given in the table of critical values χ_α (known reference number), with a significance level of 0.05 (given probability of error). In our study, a 5% possibility of

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error is allowed; that is, the reliability of the result was chosen at 95% (i.e., a probability level of 0.05). The value of χ^2_{crit} is determined for the significance level α=0.05 according to the table, and is equal to 4 − the number of degrees of freedom. Thus, 9.49 = χ^2_{crit}. If the empirical (χ^2_{emp}) value of the criterion is equal to the critical χ^2_{crit} or is less, then the null hypothesis is accepted, that is, the qualitative characteristics of the EG and CG respondents coincide with a probability of 95%. Moreover, if the empirical (χ^2_{emp}) value of the criterion is greater than the critical χ^2_{crit}, then the null hypothesis is rejected, and the alternative hypothesis is accepted. Then, with a confidence of 95%, the qualitative characteristics of the EG and CG students are considered different.

Ascertaining stage

Diagnosis of the formation of the motivational component of professional competence among respondents revealed the following:

- 79% of respondents in the CG and 81% in the EG had an average, low, or critical level.
- 21% of respondents in the CG and 19% in the EG had a sufficient, high level.

Thus, the results of the experiment show that most respondents at the beginning of the experiment had poorly formed motivational attitudes toward professional competence.

Table 1.
Formation of the motivational component of professional competence of future foreign language specialists (stating stage)

Levels	Control group %	Experimental group %
Low	18	19
Critical	32	32
Average	30	30
Sufficient	15	12
High	5	7

Let's assess the reliability of the obtained data and compare the experimental and control groups in terms of the level of formation of the motivational component of professional competence in respondents.

Let us formulate two hypotheses:

Hypothesis H_0: The control group and the experimental group of respondents do not significantly differ in the level of formation of the motivational component.

Hypothesis H_1: The control group and the experimental group of respondents differ significantly in the level of formation of the motivational component. The obtained χ^2_{emp} is less than χ^2_{crit} (0.304 < 9.49); therefore, the hypothesis H_0 is accepted: the control and experimental groups of respondents do not differ significantly in the level of formation of the motivational component.

Diagnosis of the cognitive component of professional competence in respondents showed the following:

- 79% of respondents in the CG and 78% in the EG had average, low, and critical levels.

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– 21% of respondents in the CG and 22% of respondents in the EG had a sufficient, high level.

Thus, the results of the experiment show that most respondents at the outset demonstrated insufficient knowledge of the specified problem.

Table 2.
Formation of the cognitive component of professional competence of future specialists in a foreign language (statistical stage)

Levels	Control group %	Experimental group %
Low	19	20
Critical	28	28
Average	32	30
Sufficient	14	15
High	7	7

Let us assess the reliability of the collected data and compare the experimental and control groups based on the level of cognitive development in the formation of respondents' professional competence.

Let us formulate two hypotheses:

Hypothesis H_0: The experimental group and the control group of respondents do not significantly differ in the level of formation of the cognitive component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the cognitive component. The obtained χ^2_{emp} is less than χ^2_{crit} (0.304 < 9.49); therefore, the hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the cognitive component.

Diagnosis of the epistemological component of professional competence in respondents showed the following:

– 78% of respondents in the CG and 76% in the EG had average, low, and critical levels.
– 22% of respondents in the CG and 24% of respondents in the EG had a sufficient, high level.

Thus, the results of the experiment show that at the outset, most respondents demonstrated insufficient knowledge of the specified problem.

Table 3.
Formation of the epistemological component of professional competence of future specialists in a foreign language (confirmatory stage)

Levels	Control group %	Experimental group %
Low	17	19
Critical	28	29
Average	33	28
Sufficient	16	16
High	6	8

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Let's assess the reliability of the collected data and compare the experimental and control groups regarding the level of epistemological component development in respondents.

Let us formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not significantly differ in terms of the level of formation of the epistemological component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in terms of the level of formation of the epistemological component.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is less than χ^2_{crit} (1.02 < 9.49); therefore, the hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the epistemological component.

The diagnosis of the activity component of professional competence among respondents showed the following:

- 78% of respondents in the CG and 75% in the EG had an average, low, or critical level.
- 22% of respondents in the CG and 24% in the EG had a sufficient, high level.

Therefore, at the beginning of the experiment, respondents demonstrated insufficient knowledge of the specified problem.

Table 4.
Formation of the activity component of professional competence of future foreign language specialists (statistical stage)

Levels	Control group %	Experimental group %
Low	17	19
Critical	28	29
Average	33	27
Sufficient	16	16
High	6	8

Let's assess the reliability of the obtained data and compare the experimental and control groups in terms of the level of formation of the activity component of professional competence among respondents.

Let's formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not significantly differ in the level of formation of the activity component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the activity component.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is less than χ^2_{crit} (0.435 < 9.49); therefore, the hypothesis H_0 is accepted: the experimental and

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control groups of respondents do not differ practically in the level of formation of the activity component.

The diagnosis of the communicative component of professional competence among respondents showed the following:

- 82% of respondents in the CG and 81% in the EG had an average, low, critical level.
- 18% of respondents in the CG and 19% in the EG had a sufficient, high level.

Therefore, at the beginning of the experiment, respondents demonstrated insufficient knowledge of the specified problem.

Table 5.
Formation of the communicative component of professional competence of future specialists in a foreign language (confirmatory stage)

Levels	Control group %	Experimental group %
Low	18	19
Critical	35	31
Average	28	31
Sufficient	10	13
High	8	6

Let us assess the reliability of the collected data and compare the experimental and control groups regarding the level of development of the communicative component of professional competence in respondents.

Let's formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not significantly differ in the level of formation of the communicative component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the communicative component.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is less than χ^2_{crit} (0.604 < 9.49); therefore, the hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the communicative component.

According to the results of the ascertaining stage, the respondents demonstrated insufficient depth of knowledge of the specified problem.

The formative stage of the study

Because respondents had limited knowledge of the specified problem, we developed a pedagogical technology. In the EG, pedagogical conditions for the development of professional competence in a foreign language among future specialists using digital technologies were proposed.

The pedagogical technology for the formation of professional competence in a foreign language among future specialists using digital technologies was introduced in the EG. The CGs followed the standard methodology.

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The pedagogical technology included:

- Application of scientific approaches (competence, student-centered, axiological, systemic, practice-oriented).
- Use of pedagogical principles (positive motivation for learning; developmental learning; consciousness and activity; professional orientation of education; elective learning; consistency and systematicity).
- Conducting topics on the digitalization of the content of individual components of the philological cycle.
- Selective educational components, where issues of digital technologies are thoroughly considered.
- Master class for creating educational professional products using digital technologies.
- Innovative ways of using digital technologies to form the professional competence of future foreign language specialists.
- Modern methods for the formation of the components of the professional competence of future foreign language specialists.
- Implementation of pedagogical conditions for the formation of the professional competence of future foreign language specialists using digital technologies.

Let us present the results of the formative stage of the pedagogical experiment.

We obtained empirical data at the end of the formative stage, which gave grounds to speak about the formation of professional competence in the respondents of the experimental group and the control group:

- In the EG and CG, the percentages of respondents reporting high or sufficient levels of formation of professional competence in a foreign language among future specialists through digital technologies increased. However, the relative indicators in the experimental group are much higher, and the growth is more pronounced.
- We observe significant differences between respondents with a high and sufficient level of formation of the components of their professional competence for future specialists in a foreign language using digital technologies between the experimental and control groups. It has been proven that future specialists in a foreign language in the EG developed professional competence through digital technologies at a higher level than in the CG.
- Positive results in the experiment were achieved due to the introduction of pedagogical technology.

We will show positive results for each criterion (formative stage of the study).

Diagnosis of the formation of the motivational component of professional competence of future specialists in a foreign language by means of digital technologies revealed the following:

- 73% of respondents in the CG and 46% in the EG had an average, critical, low level.
- 27% of respondents in the CG and 54% in the EG had a sufficient, high level.

Thus, the results of the experiment demonstrate the effectiveness of implementing pedagogical technology in the EG.

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The most significant difference was observed at a statistically significant level between the CG and the EG (−19%). The share of respondents in the EG with a sufficient level of this component's formation exceeds that in the CG.

Table 6.
Formation of professional competence of future specialists in a foreign language by means of digital technologies (motivational component, formative stage)

Levels	Control group %	Experimental group %
Low	13	6
Critical	24	12
Average	36	28
Sufficient	19	39
High	8	15

Let us compare the experimental and control groups in terms of the level of motivational component formation and assess the reliability of the data obtained. Let's formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not significantly differ in the level of formation of the motivational component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the motivational component of professional competence.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is greater than χ^2_{crit} (12.689 > 9.49); therefore, the hypothesis H_1 is accepted: the experimental and control groups of respondents differ significantly in the level of formation of the motivational component of professional competence.

Diagnosis of the formation of the cognitive component of professional competence of future specialists in a foreign language by means of digital technologies showed that:

- 75% of respondents in the CG and 59% in the EG had an average, critical, low level.
- 25% of respondents in the CG and 41% in the EG had a sufficient, high level.

Thus, the results of the experiment demonstrate the effectiveness of implementing pedagogical technology in the EG.

The most significant difference was observed at a sufficient level between the CG and the EG (−8%). The share of respondents in the EG with a sufficient level of this component's formation exceeds that in the CG.

Table 7.
Formation of professional competence of future specialists in a foreign language by means of digital technologies (cognitive component, formative stage)

Levels	Control group %	Experimental group %
Low	16	9
Critical	33	18
Average	26	33
Sufficient	16	24
High	9	17

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Let's compare the control and experimental groups by the level of cognitive component formation and assess the reliability of the data obtained.

Let's formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not differ significantly in the level of formation of the cognitive component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the cognitive component of professional competence.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is greater than χ^2_{crit} (9.866 > 9.49); therefore, the hypothesis H_1 is accepted: the experimental and control groups of respondents differ significantly in the level of formation of the cognitive component of professional competence.

Diagnosis of the level of formation of the epistemological component of professional competence of future specialists in a foreign language by means of digital technologies showed that:

- 77% of respondents in the CG and 62% in the EG had an average, critical, low level.
- 23% of respondents in the CG and 38% in the EG had a sufficient, high level.

Thus, the results of the experiment demonstrate the effectiveness of implementing pedagogical technology in the EG.

The most significant difference was observed at a sufficient level between the CG and the EG (−9%). The share of respondents in the EG with a sufficient level of this component's formation exceeds that in the CG.

Table 8.
Formation of professional competence of future specialists in a foreign language by means of digital technologies (epistemological component, formative stage)

Levels	Control group %	Experimental group %
Low	15	4
Critical	31	18
Average	31	40
Sufficient	15	24
High	8	14

Let us compare the experimental and control groups in terms of epistemological component formation and assess the reliability of the obtained data.
Let's formulate two hypotheses:

Hypothesis H_0: By the level of formation of the epistemological component, the experimental and control groups of respondents do not differ significantly.

Hypothesis H_1: By the level of formation of the epistemological component of professional competence, the experimental group and the control group of respondents differ significantly.

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Let's calculate the Pearson criterion. The obtained χ^2_{emp} is greater than χ^2_{crit} (10.926 > 9.49); therefore, the hypothesis H_1 is accepted: the control and experimental groups differ significantly in the level of formation of the epistemological component of professional competence.

Diagnosis of the level of formation of the activity component of professional competence of future foreign language specialists using digital technologies showed that:

- 78% of respondents in the CG and 58% in the EG had an average, critical, low level.
- 22% of respondents in the CG and 42% in the EG had a sufficient, high level.

Thus, the results of the experiment demonstrate the effectiveness of pedagogical technology in the EG.

The most significant difference was observed at a statistically significant level between the CG and the EG (−13%). The share of respondents in the EG with a sufficient level of this component's formation exceeds that in the CG.

Table 9.
Formation of professional competence of future foreign language specialists using digital technologies (activity component, formative stage)

Levels	Control group %	Experimental group %
Low	17	7
Critical	29	20
Average	32	31
Sufficient	14	28
High	8	14

Let's compare and assess the reliability of the data obtained in the experimental and control groups by the level of formation of the activity component.
Let us formulate two hypotheses:

Hypothesis H_0: The experimental and control groups of respondents do not differ significantly in terms of the level of formation of the activity component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in terms of the level of formation of the activity component of professional competence.

Let's calculate the Pearson criterion. The obtained χ^2_{emp} is greater than χ^2_{crit} (10.129 > 9.49); therefore, the hypothesis H_1 is accepted: the control and experimental groups differ significantly in the level of formation of the activity component of professional competence.

Diagnosis of the level of formation of the communicative component of professional competence of future specialists by means of digital technologies showed that:

- 78% of respondents in the CG and 62% in the EG had average, critical, or low levels.
- 22% of respondents in the CG and 38% in the EG had sufficient, high levels.

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Thus, the experimental results demonstrate the effectiveness of pedagogical technology in the EG.

The most significant difference was observed at a statistically significant level between the CG and the EG (−13%). The share of EG respondents with a sufficient level of this component's development exceeds that in the CG.

Table 10.
Formation of professional competence of future specialists in a foreign language by means of digital technologies (communicative component, formative stage)

Levels	Control group %	Experimental group %
Low	15	8
Critical	33	20
Average	30	34
Sufficient	14	27
High	8	11

In the experimental and control groups, we will assess and compare the reliability of the collected data regarding the level of development of the communicative component.

We will formulate two hypotheses:

Hypothesis H_0: The control and experimental groups of respondents do not differ significantly in terms of the level of formation of the communicative component.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in terms of the level of formation of the communicative component of professional competence.

We will calculate the Pearson criterion. The obtained χ^2_{emp} is greater than χ^2_{crit} (10.872 > 9.49); therefore, the hypothesis H_1 is accepted: regarding the level of formation of the communicative component of professional competence. The control and experimental groups of respondents differ significantly.

The analysis of the presented data from the formative experiment allows us to conclude that the experimental group, which engaged in innovative pedagogical technology, exceeds the control group in the level of formation of all the identified components of professional competence among the respondents. The analysis of the dynamics indicates positive changes in the experimental group, which are more pronounced than in the control group.

The results of the formative stage of the experiment show that between the control and experimental groups of respondents, there are statistically significant differences in the level of formation of professional competence in general and its individual components, with more significant positive changes observed in the experimental group than in the control. Therefore, we are discussing the effectiveness of innovative pedagogical technology for developing professional competence in future specialists through digital technologies.

Conclusions

The content of the digital environment for the development of professional competence among future specialists in a foreign language is presented. The

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advantages of integrating digital technologies into language teaching are demonstrated. The integration of digital technologies into language teaching ensures the transfer of skills, abilities, and knowledge to students in a specific professional field. It orients them towards independent activity, encompassing cognitive, value, motivational, and other components.

The main aspects and conditions for the development of professional competence in a foreign language among future specialists are described. It is proven that the creation of a practice-oriented digital educational environment is a significant condition for the formation of professional competence of future specialists (by involving students in the use and development of modern web resources, web technologies, and software tools during their studies at the university).

The most common computer programs for developing professional competence in a foreign language are considered.

The purpose of the experimental work was to verify the effectiveness of the developed pedagogical technology and pedagogical conditions for the development of professional competence in a foreign language among future specialists using digital technologies.

The results of the ascertaining stage of the experiment gave grounds to express preliminary assumptions regarding the formation of professional competence of future specialists in a foreign language:

- Respondents who entered the sample revealed an insufficient level of formation of all components (identified by us) of professional competences.
- Respondents in the experimental and control groups reported approximately the same levels of professional competence development, with individual-level differences that, on average, did not exceed 1.7%. Therefore, we are talking about a homogeneous sample. This is shown by the example of each component.

Due to respondents' limited knowledge of the specified problem, we developed a pedagogical technology. The EG proposed pedagogical conditions for the development of professional competence in a foreign language among future specialists using digital technologies.

The analysis of the presented data from the formative experiment allows us to conclude that the experimental group, which engaged in innovative pedagogical technology, exceeds the control group in the level of formation of all the identified components of professional competence among the respondents. The analysis of the dynamics indicates positive changes in the experimental group, which are more pronounced than in the control group.

The results of the formative stage of the experiment show that between the control and experimental groups of respondents, there are statistically significant differences in the level of formation of professional competence in general and its individual components, with more significant positive changes observed in the experimental group than in the control. Therefore, we are discussing the effectiveness of an innovative pedagogical technology for developing professional competence in future specialists through digital technologies.

Our research does not cover all aspects of this problem. Further scientific research should focus on the influence of the educational information environment on

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education to implement differentiated and individual approaches, support students' choice of an individual learning trajectory, and enhance research activities through the use of online educational resources.

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Original Article

From clicktivism to real action: Youth civic engagement in the digital age

Del clicktivismo a la acción real: El compromiso civico juvenil en la era digital

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Abstract

This study analyzes the transformation of youth civic engagement in the context of digitalization, specifically among Ukrainian university students. The objective is to identify the forms of digital participation and the barriers hindering active citizenship. The research employed a quantitative methodology based on a survey of 486 students from pedagogical universities. Results indicate a high level of digital connectivity, with 92% of respondents using social media for news consumption. However, a significant gap exists between passive consumption and active engagement; only 38% participate in online debates and 45% sign petitions. The study identifies "clicktivism" as the dominant form of participation. Key barriers include low media literacy, distrust in political institutions, and susceptibility to information manipulation. The authors conclude that while digitalization provides tools for mobilization, it does not automatically translate into effective civic action without targeted educational interventions. Recommendations include integrating media literacy into university curricula to foster critical thinking and responsible digital citizenship.

Keywords: Civil society, youth activism, digital tools, media literacy, clicktivism.

Resumen

Este estudio analiza la transformación de la participación cívica juvenil en el contexto de la digitalización, específicamente entre estudiantes universitarios ucranianos. El objetivo es identificar las formas de participación digital y las barreras que dificultan la ciudadanía activa. La investigación empleó una metodología cuantitativa basada en una encuesta a 486 estudiantes de universidades pedagógicas. Los resultados indican un alto nivel de conectividad digital, con un 92% de los encuestados utilizando las redes sociales para el consumo de noticias. Sin embargo, existe una brecha significativa entre el consumo pasivo y la participación activa; solo el 38% participa en debates en línea y el 45% firma peticiones. El estudio identifica el "activismo mediático" como la forma dominante de participación. Las principales barreras incluyen la baja alfabetización mediática, la desconfianza en las instituciones políticas y la susceptibilidad a la manipulación de la información. Los autores concluyen que, si bien la digitalización proporciona herramientas para la movilización, no se traduce automáticamente en una acción cívica efectiva sin intervenciones educativas específicas. Las recomendaciones incluyen la integración de la alfabetización mediática en los planes de estudio universitarios para fomentar el pensamiento crítico y una ciudadanía digital responsable.

Palabras clave: sociedad civil, activismo juvenil, herramientas digitales, alfabetización mediática, activismo mediático.

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Introduction

Youth civic activity ensures young people's participation in public organizations and initiatives that improve society's quality of life. Civic activity can be informal and formal, covering actions aimed at implementing social changes in society – participation in youth initiatives and movements, starting with volunteering. Youth activity is a component of civil society, which plays a key role in supporting democratic values and fostering social interaction.

In the modern context of Ukraine, digitalization acquires not only a technological but also a distinct social dimension. In the context of military challenges, internal and external migration, transformation of social ties, and the growing need for mutual support, digital technologies act as an important tool for strengthening social cohesion. They ensure continuity of communication, access to education, social and cultural resources, and contribute to the formation of common values, civic identity, and solidarity. Thus, digitalization in Ukraine appears as a factor not only in modernizing social processes but also in consolidating society, which is critically important for its stability and further development.

Today, modern education is undergoing significant changes, aligned with the requirements of the information society, which are associated with defining new goals and modernizing legal, managerial, economic, and organizational frameworks. The role of civic education is strengthened in ensuring the educational potential of the educational process, the development of democratic principles within the educational process of an educational institution, and the organization of youth social practice in the information society. The implementation of the training of a competitive, active personality, competent in solving professional problems, life problems, a personality responsible for the development of their country and their own well-being, ready to fulfill civic duties, requires a social order from the education system. Therefore, fostering youth civic engagement through the digitalization of educational spaces in training and professional activities is important.

The digitalization of youth civic activity fosters consciousness and responsibility in public, political, and social life. This process is of decisive importance for the development of an active civic stance among youth, enabling them to promote societal well-being, defend common values, and participate in democratic processes worldwide. Through participation in community life, education, and professional activities, young people gain knowledge, the skills to collaborate with peers, an attitude toward solving social problems, and the ability to shape a personal future within a broader social context.

One of the key foundations for the formation of national solidarity is the civic activity of a young person, because without the active participation of young people in the life of the country, their deep concern for the future of the Motherland and full involvement in society are impossible; therefore, the topic chosen for the study is relevant and timely.

Literature Review

The problem of fostering youth civic activity through digitalization is consistently addressed in the work of scientists from various countries who have studied contemporary aspects of civic education. Scientific research, building on the pedagogical, political, theoretical, and psychological achievements of their predecessors, has created a methodologically sound field for studying how to foster youth civic activity through digitalization.

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Perry-Hazan & Nir (2016), when forming youth civic engagement, describes five categories of participation: sharing responsibility and power in the decision-making process with the individual, listening to the individual, taking into account and accepting the individual's voice, supporting the individual in their desire to express their views, and involving youth in the decision-making process.

The issues of socio-pedagogical support for youth and the formation of youth civic activity are the subject of the work of scientists such as Fejes et al. (2024). Scientists have proven the significant and effective participation of youth in the future, in the management of educational institutions and projects, with the help of which young people become active citizens of the state, are more willing to get involved in public organizations, participate in voting, are interested in the life of the educational institution, and are active members of the educational community.

The integration of the researchers' scientific views indicates that civic education is the primary means of developing youth civic activity. Damiani et al. (2024) focus on actions aimed at solving economic and social problems, demonstrating the use of social media to disseminate information to mobilize youth, which, through the organization of mass actions, should become an engine of change in society, since young people actively use their platforms to support humanitarian initiatives and express solidarity with those affected by the conflict. Civic activity among youth, in this case, becomes a key element in the protection of human rights during crises and in the pursuit of justice.

The study by Uribe (2017) is significant because it shows the concern about civic education in Mexico, as in other Latin American countries, related to the democratic and social crisis that Mexico has experienced, and suggests ways to solve this problem that are necessary after a long-standing desire for democracy and democratic governments, war, social conflicts around the world, because civic education as peace education is constantly evolving.

Naanous & Broom (2017) have developed a dynamic model of youth behavior and attitudes toward civic life. A theory of youth attitudes and actions is proposed, grounded in the interaction of external and internal factors that shape a particular civic mentality among young people. Internal factors are elements that reflect attitudes, personality traits, knowledge, and sense of efficacy. School, family, and culture are external elements.

Kanacri et al. (2021) have identified and described a framework for supporting a cohesive and democratic society, as the quality of social interaction between groups and individuals is increasingly recognized. The study focuses on incorporating empirical local data and systematizing knowledge on the predictors of civic engagement that ensure social cohesion in Latin America, using Chile as an example. The Naccians propose three empirical studies developed in the Chilean context. The first is an investigation into the interaction among school factors, the civic participation of Chilean adolescents, and civic self-efficacy. The second is an investigation of the trajectory of cohesive classes in a heterogeneous and multicultural environment. The third is a study aimed at civic engagement among young Chileans and the promotion of prosocial behavior among individuals of different socioeconomic statuses.

Civic engagement is a multidimensional concept, and low levels of participation in mainstream politics among young people are often interpreted as an indicator of lower civic engagement. The study by Varela Candia et al. (2015) questions the

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central role of participation as a key indicator of civic engagement in mainstream political activity and assesses the extent to which young people pay attention to mainstream politics as an indicator of civic engagement. The results of a logistic regression analysis of a sample of Chilean youth classified as political or apolitical indicate that membership in a political group predicts participation in mainstream political activity. In contrast, membership in an apolitical group predicts local-level participation. The individual's level of civic competence, tolerance, and non-traditional political participation was not a predictor of membership in any of the groups. The results prove that participation in mainstream political activity is not the leading indicator of civic engagement, and also emphasize the need and importance of developing models of civic engagement Schulz et al. (2024) emphasize the importance of trust between young people, the need for social ties for active participation in social processes, and argue that community activity through digitalization increases the level of civic responsibility. In contrast, a decline in social activity weakens democracy.

An analytical review of scientific works on the problem addressed in the selected study indicates that the development of youth civic activity through digitalization remains an important task in modern education.

Purpose of the article. Formation of civic activity of youth by means of digitalization.

Methodology

Research Design

This study employed a quantitative quasi-experimental research design to examine the effectiveness of pedagogical conditions aimed at fostering youth civic engagement through digitalization. The research was conducted during the 2024–2025 academic year and consisted of three stages: ascertaining, formative, and control.

Participants and Sampling

The study involved 217 university students enrolled in pedagogical higher education institutions in Ukraine. Participants were divided into an experimental group (EG, n = 113) and a control group (CG, n = 104).

A stratified random sampling technique was used to ensure the sample's representativeness. The general population was divided into homogeneous strata by institutional affiliation, and respondents were randomly selected from each stratum. The equivalence of the experimental and control groups was verified using the Wilcoxon–Mann–Whitney U test, which showed no statistically significant differences between groups at the initial stage ($p > 0.05$).

Instruments and Measures

Data collection was carried out using a set of standardized and author-designed diagnostic tools, including:

- Structured questionnaires.
- Pedagogical testing.
- Situational tasks.
- Unfinished sentence techniques.

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Youth civic engagement was operationalized through **three criteria**:

1. **Motivational–value criterion** (civic values, attitudes, and motivation).
2. **Behavioral–activity criterion** (participation in civic and socially significant activities).
3. **Reflective–evaluative criterion** (civic self-awareness, responsibility, and social reflection).

Based on these criteria, three levels of civic engagement were identified: high, medium, and low.

Experimental Procedure

The formative intervention in the experimental group was based on the implementation of pedagogical conditions integrating digital tools, including:

- A specially designed course *"Innovations in the Education of Responsible and Active Citizens"*.
- Participation in digital civic projects.
- Online master classes and webinars.
- Engagement with social media platforms for civic initiatives.

The control group followed the standard educational curriculum without targeted digital civic engagement interventions.

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistical methods.

The following statistical procedures were applied:

- **Pearson's chi-square test (χ^2)** to compare the distribution of civic engagement levels between groups.
- **Fisher's angular transformation (φ-test)** to assess the significance of differences in proportions.
- Calculation of **p-values** to determine statistical significance ($\alpha = 0.05$).

Statistical analyses were performed using Microsoft Excel (XI2TEST function) and online statistical calculators.

Ethical Considerations

Participation in the study was voluntary and anonymous. All respondents were informed about the purpose of the research and provided informed consent. The study complied with ethical standards for educational and social research.

Results and Discussion

The role of youth civic activity through digitalization and participation in state-building. Basic principles and types of youth civic engagement. Rules governing the use of ICT and materials for youth civic engagement are available online.

Youth civic engagement through digitalization is essential for preparing young people to actively participate in democratic processes. In countries like the USA and

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Canada, students are involved in analyzing socio-political issues, understanding democratic values, and engaging with civil society through digital tools. In Europe, civic education emphasizes developing youth civic competencies via digitalization, as reflected in the Council of Europe's Competence Framework and the European Charter, which stress active participation in public life beyond elections.

Youth participation fosters social cohesion, strengthens civic values, and allows young people to influence state and global decisions, becoming active agents rather than passive observers of society (Middaugh et al., 2025). Civic activity through digitalization encourages involvement in decision-making, responsibility, and initiative. Key types include:

- Joining democratic institutions digitally, proposing ideas, and participating in meetings.
- Engagement in educational institution life.
- Situational participation linked to one-time events.
- Open participation in community or city decision-making via digital platforms.
- Representative participation through student councils or youth parliaments.
- Involvement in social projects.

Developing civic readiness requires an educational environment aligned with personal values, opportunities to respond to digital challenges, and active roles in society. Core principles include subject-subject interaction, activity, independence, and self-directed meaningful participation (Norabuena-Figueroa et al., 2025).

ICT is essential for organizing civic activity. Basic rules for using digital tools include:

- Using popular search engines.
- Selecting resources from educational and public websites or electronic libraries.
- Choosing suitable ICT tools for presenting research.
- Following safe online behavior.
- Maintaining a critical, responsible civic stance.
- Observing proper presentation practices.

Key programs for the formation of youth civic activity through digitalization.

Approaches to fostering youth civic engagement through digitalization vary across countries and educational systems but share a common goal: educating responsible and active citizens capable of participating in democratic processes and addressing social challenges. In the United States, civic education is systematically integrated into curricula through digital tools, focusing on constitutional principles, democratic values, and citizens' rights and responsibilities (Yang & Ogawa, 2022).

Among the most influential initiatives is We the People, which promotes civic knowledge and engagement through competitions, project-based learning, and curriculum modules that encourage youth to apply democratic principles in practice (DiGiacomo, 2021). Closely related is Project Citizen, where students address real community issues by developing policy proposals, engaging with local authorities, and creating digital portfolios, thereby strengthening civic responsibility and participatory skills (Reis & Dayrell, 2020; Zukerfeld et al., 2024).

Digital civic education is further supported by iCivics, a nonprofit platform offering interactive resources and educational games that enhance understanding of government, democracy, and human rights through game-based learning

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(De Coninck et al., 2025). At the advanced level, Civic Action Projects (CAP) foster leadership, public–private collaboration, and innovative policymaking by engaging youth in solving complex societal problems (Sádaba, 2022; Souza De Oliveira & Sommer, 2017).

In addition, national and international volunteer programs such as AmeriCorps and the Peace Corps provide digitally supported pathways for youth participation in social, educational, environmental, and humanitarian initiatives, contributing to the development of civic responsibility and global solidarity (del Moral Pérez et al., 2021).

Overall, these programs demonstrate that digitalization significantly enhances youth civic engagement by combining civic education, project-based learning, and volunteering, thereby fostering active citizenship and democratic participation in contemporary societies (Caldeiro-Pedreira et al., 2021).

Interpretation Through Theories of Political Disaffection

Political disaffection describes a persistent negative attitude toward the political system and actors, including low trust, disengagement, and skepticism about democratic processes. Key theoretical perspectives (e.g., from Nie et al., Dalton, and Klingemann) identify three core dimensions of political disaffection: (1) distrust in political institutions, (2) perceived ineffectiveness of political actors, and (3) low motivation for political participation. These dimensions often emerge where citizens feel alienated from formal political processes and believe that their participation yields minimal influence on outcomes.

Our study's findings align with these theoretical constructs: high levels of disaffection among youth (e.g., elevated mistrust or reduced civic engagement scores) reflect alienation and skepticism consistent with classical political disaffection frameworks. Such attitudes are typically associated with institutional distrust and perceptions of democratic underperformance, reinforcing the notion that citizens may adopt a detached or passive stance toward political participation when they perceive systemic inadequacies or elite unresponsiveness.

Comparison With EU Averages and Trends

When comparing our results with broader European data, some relevant patterns emerge:

1. General European Disaffection Trends

   - Surveys indicate that a majority of Europeans report dissatisfaction or ambivalence toward democracy. For example, a European Movement survey found that only 36 % of respondents consistently support democratic principles, while the remaining 64 % show inconsistent support or preference for stronger leadership—a form of political disaffection manifested as conditional support for democratic norms.

2. Dissatisfaction with Democracy Across the EU:

   - According to *Statista* data, the EU average dissatisfaction with both domestic and EU-level democracy is around 42 %—suggesting a

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substantial share of citizens in the EU feel disaffected toward political institutions and processes.
- Dissatisfaction with democracies varies regionally within EU countries, with some post-2004 members experiencing larger gaps between democratic expectations and perceptions of democratic functioning.

3. Perceived Democratic Deficit:

- Specific measures of democratic deficit in countries like Greece (≈51 %) and Hungary (≈50 %) indicate that many citizens believe their governments fail to act in the broad public interest—a central element of political disaffection.

Comparison to Our Results:

- If the percentages of youth showing political apathy or distrust in our study are higher than EU averages (~42 %), this would suggest exacerbated disaffection in the studied population compared with the broader European context.
- If they are similar or slightly lower, this might indicate convergence with EU-level political sentiment, where disaffection is widespread but not uniquely intensified among youth in the study context.

Overall, our results mirror broader EU trends of skepticism toward democratic institutions and processes, reinforcing arguments that political disaffection is not isolated but part of a wider European phenomenon, particularly among younger generations. However, while support for the EU itself has risen in some polls (e.g., 74 % see EU membership as beneficial), this does not fully translate into trust in political systems or active civic engagement, suggesting that political disaffection manifests differentially across institutional levels (EU vs. national politics).

Implications for Theory and Policy

The alignment between our findings and EU trends underscores the salience of political disaffection as a structural issue affecting civic engagement, particularly among youth. It suggests that democratic resilience may require both institutional reforms and targeted civic education strategies that address not only procedural participation (e.g., voting) but also perceptions of political efficacy and trust.

Organization and course of the experimental study

The formation of youth civic activity by means of digitalization involves a set of stages of predicted, planned work from the set goal to the result, namely:

- Preparatory stage, the formation of positive emotions in civic activity, the acceptance of society as a value, a collective activity.
- Organizational and activity stage of the formation of youth civic activity through digitalization involves the development of the ability to solve tasks and civic problems rationally.
- Reflective and evaluative stage of the formation of youth civic activity by means of digitalization, awareness of the civic position, the application of knowledge and creative abilities in civically significant activities.

To foster youth civic activity through digitalization, criteria, indicators, and levels of its formation have been established.

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Indicators of the motivational criterion − content of civic activity are: knowledge of the essence of civic relations, civic youth; knowledge of the nature of such civic qualities as civic responsibility, solidarity, social responsibility, tolerance, youth civic activity, and civic activity.

Indicators of the performance criterion – the manifestation of civic activity are: participation, based on universal human values, in civic activity; awareness of oneself as a citizen of one's country, the presence of civic feelings; the desire to acquire solidarity, social responsibility, tolerance, civic activity of youth, and civic activity.

Indicators of the evaluation criterion – the manifestation of civic activity in youth are: the manifestation of a civic active position of youth towards current social problems; the presence of communication skills when interacting with other individuals, civic activity, the manifestation of solidarity, social responsibility, tolerance, civic activity of youth, and civic activity.

The levels of youth civic activity are determined as **high**, **average**, and **low**.

The ascertaining stage of the experiment proved, based on the results of the study, that a significant majority of youth who participated in the experiment showed low and medium levels of formation of civic activity of youth:

EG:

- The average level of civic activity among youth was reported by 50% of respondents.
- 33% of respondents showed a low level of formation of youth civic activity.
- 17% of respondents showed a high level of formation of youth civic activity.

The results of the study at the ascertaining stage indicate that the general level of youth civic activity formation does not meet social requirements and requires systematic efforts to improve it.

Therefore, based on the results of diagnosing the levels of formation of youth civic activity and based on the analysis of scientific sources, to ensure the effectiveness of the process of forming personal qualities and youth civic activity, we developed pedagogical conditions that were implemented in the educational process of EG respondents:

- Updating the methodological support and content of the educational process during the formation of youth civic activity.
- Improving the methodological and theoretical readiness of youth to use computer technologies in the formation of civic activity.
- Involving young people in socially significant activities of self-government aimed at forming civic activity, educating responsible, active citizens who will be ready to build society and participate in democratic processes.

Respondents of the CG continued their studies according to the usual program.

To form civic activity of young people, based on the results of the analysis of the innovative activity of respondents, we offered a special course developed for the respondents of the experimental group "Innovations in the education of responsible, active citizens who will be ready to build society and participate in democratic

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processes", the purpose of which was to familiarize young people with the strategy of forming civic activity in the educational process and throughout life, improve the professional skills of young people, motivate them for professional development, develop individuality, create the ability of young people to make changes in their own lives and stimulate social activity.

Individual approaches to fostering civic activity in the educational process in the EG included the use of Internet resources, consultations, self-education, and participation in webinars and programs for personal development. Group-based forms of civic activity included master classes, creative group work, methodological support programs, seminars, conferences, training sessions, business games, etc.

The EG paid attention to the formation of youth civic activity, the real participation of citizens in the exercise of state power, in education, the harmonious combination of the interests of the state and the citizen, equality regardless of nationality, race, gender of citizens, active participation of youth in various types of socially oriented, collective, individual activities, orientation on the active life position of the individual. An effective means of forming youth civic activity was project activity, which provided applicants for educational space with the opportunity to correlate and integrate their personal perspectives obtained in the process of learning with the real world in which they exist, as well as with socio-political events and public life taking place within the educational institution or local community. During the project activities, young people drew on existing knowledge, collaborated and communicated with one another, and demonstrated their active civic stance.

During the implementation of the developed system for the formation of youth civic activity, we focused on popularizing the activities of youth centers, conducting an information campaign on the innovative activities of public organizations, involving youth in volunteer activities, disseminating knowledge about the political and social system in society, creating a website, and pages on social networks Instagram and Facebook.

A practical step during the information stage of implementing the system for the formation of youth civic activity by means of digitalization in the framework of the special course "Innovations in the education of responsible, active citizens who will be ready to build society and participate in democratic processes" was the involvement of young people in the project "Formation of youth civic activity by means of digitalization" and master classes.

Analysis of the results of experimental work

The control experiment was conducted at the final stage of the study to compare the levels of civic activity formation among youth through digitalization in the control and experimental groups, after the formative stage of the experiment had been completed. According to the criteria, indicators, and levels of the formation of youth civic activity through digitalization established at the beginning of the study, a control section was conducted, and the methods used at the ascertaining stage of the experiment were also employed.

At the final stage of the experimental work, at the end of the 2024-2025 academic year, a control section was carried out.

Two hundred seventeen respondents (113 – EG; 104 – CG) participated in the experimental verification of the effectiveness of substantiated pedagogical conditions for the development of youth civic activity through digitalization.

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The qualitative composition of the sample was established through a stratified sampling method, which involved dividing the general population into strata and then randomly selecting respondents from each stratum. Using the empirical Wilcoxon-Mann-Whitney test, the qualitative composition of participants in the experimental and control groups was tested using a software tool. The critical value is 1.96, so the critical value for this test is 0.3731. The qualitative and quantitative composition of reviewers in the control and experimental groups is approximately the same, as the significance level of 0.05 indicates that the characteristics of the samples being compared are comparable.

We characterized the sample through representativeness. The level of foster youth civic activity through digitalization corresponds to the level of civic activity among all respondents who participated in the study.

The development of youth civic activity through digitalization in the EG occurred in three stages: the preparatory stage, the main stage, and the generalizing stage.

Using the Pearson test, the distribution of respondents across levels of civic activity formation was compared. The Excel XI2TEST function was used for calculations.

Using an online calculator, the p-level was calculated using the Fisher test.

H_0: The proportion of reviewers in the experimental group with a high level of civic activity does not differ from the proportion of reviewers in the control group.
H_1: The activity of respondents (proportion) in the experimental group with a high level of civic activity is significantly different from that of the control group.

The distribution of respondents in the experimental and control groups by level of civic activity formation at the ascertaining stage does not differ ($p = 0.0001$). In contrast, at the formative stage of the experiment, it does differ ($p=0.9843$).

Therefore, the data obtained confirmed the distribution of respondents into the control and experimental groups, which is objective for the formative experiment.

According to the results of the ascertaining stage of the experiment, the following results were obtained (Fig. 1):

EG:

- 17% of respondents had a high level of civic activity.
- 50% of respondents had an average level of civic activity.
- 33% of respondents had a low level of civic activity.

CG:

- 16% of respondents had a high level of civic activity.
- 50% of respondents had an average level of civic activity.
- 34% of respondents had a low level of civic activity.

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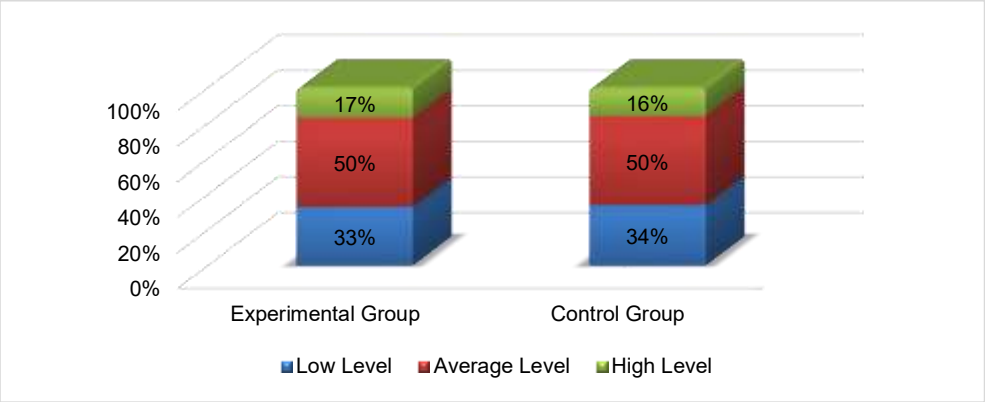


Fig. 1. Distribution of civic activity levels in the experimental and control groups at the ascertaining stage.

That is, the majority of respondents showed average and low levels of civic activity. Conducting the main stage of the experiment on the formation of youth civic activity through digitalization involved focusing EG respondents' attention on the implementation of clearly defined and justified pedagogical conditions necessary for this process.

We present the overall averaged results from the control section of the experiment, which was conducted to assess the effectiveness of the experimental results.

In the experimental group, our results showed a significant increase in civic activity among youth through digitalization compared with the control group (Table 1, Fig. 2).

Table 1.
Dynamics of the levels of formation of civic activity of youth (results of the ascertaining and formative stages of the experiment)

Levels	Experimental group		Dynamics	Control group		Dynamics
	At the beginning of the experiment	At the end of the experiment		At the beginning of the experiment	At the end of the experiment	
	%	%	%	%	%	%
High	17	32	**+15**	16	18	**+2**
Average	50	60	**+10**	50	52	**+2**
Low	33	8	**-25**	34	30	**-4**

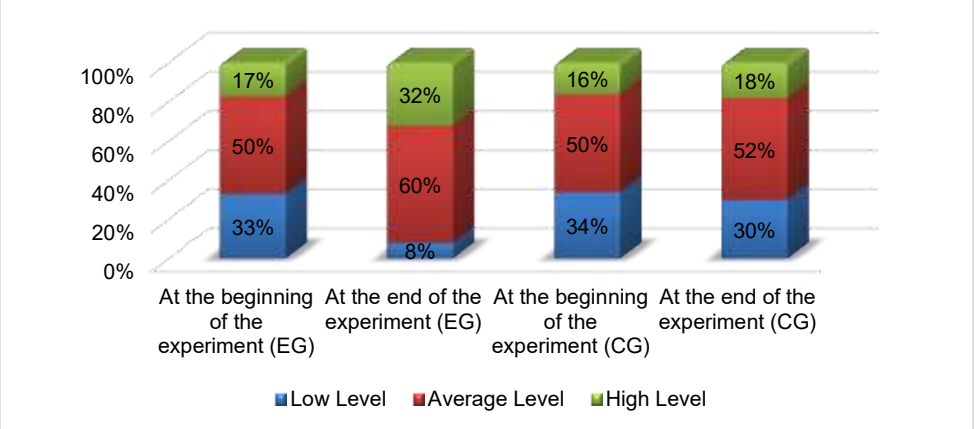


Fig. 2. Dynamics of the levels of formation of civic activity of youth (results of the ascertaining and formative stages of the experiment)

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Thus: the shift in the share of high levels of civic activity formation according to Fisher's test, in the reviewers of the experimental group was p-level 0.0183 and 16.2 − by xi-square; the shift in the share of average levels of civic activity formation according to Fisher's test, in the reviewers of the experimental group was p-level – 0.0145, and by xi-square 6.197; the shift in the share of low levels of civic activity formation according to Fisher's test, in the reviewers of the experimental group was p-level – 0.0001, by xi-square – 45.87.

The number of high school students in the experimental group who demonstrate conscious knowledge of moral and legal norms, civic relations, civic activity, rules of behavior, give a meaningful characteristic of civic concepts, can establish connections between them has increased; demonstrate deep knowledge of the essence of such civic qualities as: solidarity, tolerance, civic responsibility, initiative; demonstrate civic feelings, respect for civic values, moral and legal norms; demonstrate a value-based attitude, strive to participate in civic activity, realize themselves as citizens of an innovative society; demonstrate an active civic position towards current social problems; possess communication skills.

The results showed a significant increase in the proportion of respondents with an average or high level of civic activity in the experimental group compared with the control group. These statistical indicators in the EG significantly exceed the results obtained in the CG. Analysis of the control group's comparative results shows no significant positive changes in young people's civic activity attributable to digitalization.

Therefore, the results of the research and experimental work demonstrated the effectiveness of the developed and substantiated pedagogical conditions for the development of youth civic activity through digitalization methods, implemented in the EG.

Conclusions

The role of youth civic activity in digitalization and state-building is demonstrated; the basic principles and types of youth civic activity formation are highlighted; and guidelines for the use of ICT and online materials for the formation of youth civic activity are proposed.

Key programs for fostering youth civic activity through digitalization are described. The ascertaining stage of the experiment, based on the study's results, indicated that a substantial majority of the youth who participated exhibited low to moderate levels of civic activity.

The results of the study at the ascertaining stage indicate that the general level of youth civic activity formation does not meet social requirements and requires systematic efforts to improve it.

Therefore, based on the results of diagnosing the levels of youth civic activity formation and an analysis of scientific sources, to ensure the effectiveness of the process of developing personal qualities and youth civic activity, we created pedagogical conditions that were implemented in the educational process for EG respondents. The CG respondents continued their studies according to the usual program.

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To form the civic activity of youth based on the results of the analysis of the innovative activity of the respondents, we offered a special course developed for the respondents of the experimental group "Innovations in the education of responsible, active citizens who will be ready to build society and participate in democratic processes", the purpose of which was to familiarize young people with the strategy of forming civic activity in the educational process and throughout life, to increase the professional skills of young people, to motivate them for professional development, to develop their individuality, to form the ability of young people to make changes in their own lives and to stimulate social activity.

A practical step during the information stage of implementing the system of forming civic activity of youth by means of digitalization, in addition to the special course "Innovations in the education of responsible, active citizens who will be ready to build society and participate in democratic processes", was the involvement of young people in the project "Forming civic activity of youth by means of digitalization" and master classes.

The control experiment was conducted at the final stage of the study to compare the levels of civic activity among youth through digitalization in the control and experimental groups, after the formative stage of the experiment had been completed. According to the criteria, indicators, and levels of the formation of youth civic activity through digitalization defined at the beginning of the study, a control section was conducted, and the methods used at the ascertaining stage of the experiment were also employed.

In the experimental group, our results showed a significant increase in civic activity among youth through digitalization compared with the control group.

The results showed a significant increase in the number of respondents with an average or high level of civic activity formation in the experimental group compared with the control group. These statistical indicators in the EG significantly exceed the results obtained in the CG. Analysis of the control group's comparative results shows no significant positive changes in the formation of youth civic activity through digitalization.

Therefore, the results of the research and experimental work have demonstrated the effectiveness of the developed, substantiated, and implemented EG pedagogical conditions for the formation of youth civic activity through digitalization.

To strengthen youth civic engagement through digitalization, universities should adopt targeted and evidence-based strategies.

First, civic and digital citizenship education should be systematically integrated into university curricula through mandatory modules focusing on digital rights, democratic participation, and ethical online behavior. Particular attention should be paid to developing critical thinking and media literacy.

Second, universities should implement practical media literacy interventions, such as workshops on fake news verification, fact-checking techniques, and critical analysis of social media content, to reduce passive “clicktivism” and vulnerability to information manipulation.

Third, student participation in digital civic projects should be expanded. Universities are encouraged to support project-based learning linked to real community

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problems, where students design and implement online civic initiatives, with such activities recognized within the credit system.

Fourth, digital tools should be used to enhance student self-governance, including online platforms for consultations, discussions, and voting, thereby increasing students' sense of political efficacy and trust in institutional decision-making.

Finally, universities should invest in faculty training on digital civic education and regularly monitor students' civic engagement levels to ensure continuous improvement of educational practices.

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Original Article

Professional competence and digital literacy in pre-service art teachers

Competencia profesional y alfabetización digital en futuros docentes de arte

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Abstract

The study examines the effectiveness of digitally oriented pedagogical conditions for the formation of professional competence in future art teachers. The aim of this study is to evaluate the effectiveness of pedagogical conditions for the formation of professional competence in future art teachers through the integration of digital technologies. The research employed a mixed-methods quasi-experimental design involving 124 pre-service art teachers, divided into an experimental group (n = 60) and a control group (n = 64). Professional competence was assessed using motivational, cognitive, and creative–activity criteria through questionnaires, tests, self-assessment tools, interviews, and pedagogical observation. The experimental group was trained using a competency-based digital model, while the control group followed a traditional program. The findings confirm that the systematic integration of digital technologies within a competency-based framework leads to measurable improvements in the professional competence of future art teachers.

Keywords: digitalization, professional competence, future art teachers, digital literacy of the individual, innovation process.

Resumen

El estudio examina la efectividad de las condiciones pedagógicas orientadas digitalmente para la formación de competencias profesionales en futuros profesores de arte. El objetivo de este estudio es evaluar la efectividad de las condiciones pedagógicas para la formación de competencias profesionales en futuros profesores de arte a través de la integración de tecnologías digitales. La investigación empleó un diseño cuasiexperimental de métodos mixtos que involucró a 124 futuros profesores de arte, divididos en un grupo experimental (n = 60) y un grupo de control (n = 64). La competencia profesional se evaluó utilizando criterios motivacionales, cognitivos y de actividad creativa a través de cuestionarios, pruebas, herramientas de autoevaluación, entrevistas y observación pedagógica. El grupo experimental fue entrenado utilizando un modelo digital basado en competencias, mientras que el grupo de control siguió un programa tradicional. Los hallazgos confirman que la integración sistemática de las tecnologías digitales dentro de un marco basado en competencias conduce a mejoras mensurables en la competencia profesional de los futuros profesores de arte.

Palabras clave: digitalización, competencia profesional, futuros profesores de arte, alfabetización digital del individuo, proceso de innovación.

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Introduction

Digitalization of education is a defining trend in modern educational development and significantly transforms the requirements for the professional training of future teachers, particularly in the field of art education. In the context of the transition to a digital educational environment, not only are the teaching tools changing, but also the very structure of the professional competence of an art teacher, which increasingly combines pedagogical, artistic, creative, and digital components (Espinoza-Castro et al., 2025). However, the practice of training future art teachers in higher education institutions indicates significant difficulties in systematically integrating digital technologies into professionally oriented training, which negatively affects graduates' readiness for effective pedagogical activity in a digital educational environment (Messuti, 2017).

An analysis of modern research shows that scientists are actively considering the problems of digitalization of pedagogical education, the development of digital literacy and the use of digital tools in the artistic training of future teachers. At the same time, the majority of works focus either on general pedagogical aspects of digital competence or on individual digital tools and technologies, without taking into account the specifics of the professional activity of an art teacher as a combination of artistic and creative, communicative and pedagogical activities UNESCO Institute for Statistics (2018). The integrative aspect of the professional competence of future art teachers remains insufficiently researched, in particular the coordinated formation of motivational, cognitive and creative-activity components in the process of purposeful digitalization of professional training (García-Huidobro Munita & Ferrada Sulivan, 2020). This gap, confirmed by the latest scientific publications, determines the need to develop and experimentally test pedagogical conditions that ensure the systematic formation of professional competence of future art teachers using digital technologies.

Literature Review

The formation of professional competence of future art teachers is considered in contemporary pedagogical research as a complex and multidimensional process that integrates pedagogical knowledge, artistic creativity, communicative skills, and value orientations (Gavilanes-Sagnay et al., 2019). Scholars emphasize that professional competence in art education cannot be reduced to subject mastery alone, as it also involves the ability to interpret artistic meanings, facilitate creative expression, and support students' personal and cultural development. However, many studies conceptualize professional competence within relatively stable educational contexts, without fully accounting for the structural changes introduced by the digital transformation of higher education (González-Quiñones et al., 2018; Nella Escala et al., 2024).

Comparative analysis of international research indicates a growing recognition that digitalization reshapes the professional roles and responsibilities of teachers, including those in the arts. Nevertheless, the specific mechanisms through which digitalization influences the formation of professional competence in pre-service art teachers remain insufficiently theorized and empirically validated (Pérez, 2023).

Digital competence is increasingly viewed as an essential structural component of teachers' professional competence. Research demonstrates that the ability to use digital tools meaningfully enhances pedagogical effectiveness, supports innovative teaching practices, and expands opportunities for professional self-development. In

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art education, digital competence acquires particular importance due to the growing role of visual media, multimodal texts, and digital creative tools.

Gavaldon & McGarr (2019) show that the use of comics and graphic narratives in teacher education strengthens future teachers' ability to communicate complex ideas through visual and verbal means. Their findings indicate that digital visual storytelling not only improves learning outcomes but also contributes to the development of professional skills relevant to contemporary art education. At the same time, these studies focus primarily on specific digital tools, leaving open the question of how such practices contribute to the holistic formation of professional competence.

Chen & Gao (2025), Bacca-Pachón & Sierra-Castro, (2022) examined the effect of digital literacy on art teachers' intention to integrate ICT using the Extended Technology Acceptance Model (TAM2). Surveying 580 teachers and applying structural equation modeling, they found that digital literacy significantly influences perceived usefulness and perceived ease of use, and that the model explains 65% of the variance in ICT integration intention. Subjective norms had both direct and indirect effects (via image and perceived usefulness), while ICT output quality positively affected perceived usefulness; job relevance and result demonstrability were not significant. The study underscores digital literacy as a key driver of ICT adoption and highlights the role of social norms and ICT quality in supporting technology integration in art education.

Digital teaching methodologies in art education represent a rapidly developing research area. Scholars explore blended learning, online platforms, and digitally mediated creative practices as means of enhancing student engagement and expanding artistic expression. Gavaldon & McGarr (2019) emphasize the pedagogical potential of digital narratives, while Gutiérrez-Cabello Barragán et al. (2021) analyze critical artistic practices in digital environments, demonstrating how digitalization reshapes artistic literacy and pedagogical interaction in higher education.

Some studies included in this review originate outside the narrow field of art education but offer conceptually relevant insights. For example, Meyer (2022), examining digitalization in martial arts education, provides transferable perspectives on embodiment, virtual interaction, and the transformation of practice-based disciplines in digital contexts. Although the disciplinary focus differs, the study is relevant for understanding how digital environments influence experiential and creative learning –core elements also central to art teacher education. Nevertheless, such studies rarely address pedagogical conditions tailored specifically to the professional preparation of future art teachers.

McDougald's (2018) research on CLIL methodology contributes an additional cross-disciplinary perspective, highlighting the role of integrative and competency-oriented teaching approaches in fostering lifelong learning and cultural competence. While not exclusively focused on art education, this work supports the argument that digitalization requires holistic methodological frameworks that transcend single-subject boundaries.

However, most reviewed studies either focus on descriptive analysis or lack experimental validation of assessment tools. There is limited empirical evidence demonstrating how specific pedagogical conditions and digital methodologies influence measurable changes in the professional competence of future art

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teachers. Moreover, comparative experimental designs that contrast traditional and digitalized training models remain scarce.

The reviewed literature demonstrates substantial progress in understanding professional competence, digital competence, and digital teaching methodologies in education. However, a clear research gap persists at their intersection within the context of pre-service art teacher education. Specifically, there is a lack of integrative studies that: conceptualize digital competence as a structural component of professional competence in future art teachers, implement and empirically test pedagogical conditions for competence formation through digitalization, and employ a multidimensional assessment framework within an experimental research design. Addressing this gap provides the conceptual and methodological foundation for the present study and directly informs its objective and research methodology.

Methodology

Research design

The study employed a mixed-methods quasi-experimental design aimed at examining the effectiveness of pedagogical conditions for the formation of professional competence in future art teachers through digitalization. The research combined theoretical analysis with empirical methods and included three sequential stages: the ascertaining (diagnostic), formative, and control stages. This design enabled both the identification of the initial level of professional competence and the assessment of changes resulting from the implementation of digitally oriented pedagogical interventions.

Participants

The empirical study was conducted during 2023–2025 and involved 124 pre-service art teachers enrolled in higher education institutions. Participants were divided into an experimental group (EG, n = 60) and a control group (CG, n = 64). Group allocation was based on the principle of comparability to ensure homogeneity in terms of age, educational background, and initial level of professional competence. Prior to the formative intervention, an initial diagnostic assessment confirmed that there were no statistically significant differences between the experimental and control groups regarding the key indicators of professional competence. Participation in the study was voluntary, and ethical principles of anonymity and confidentiality were observed throughout the research process.

Conceptual framework and variables

Professional competence of future art teachers was conceptualized as an integrative construct comprising three interrelated components:

- Motivational component, reflecting value orientations, professional motivation, self-esteem, and readiness for professional development.
- Cognitive component, encompassing professional knowledge, cognitive interests, self-regulation, and reflective abilities.
- Creative–activity component, including professional skills, communication, empathy, and creative expression.

The independent variable was the implementation of pedagogical conditions for competence formation through digitalization, while the dependent variable was the level of professional competence development across the defined components.

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Pedagogical intervention

The formative stage of the experiment involved the implementation of a set of pedagogical conditions in the experimental group, including:

- Motivation enhancement for professional competence development through digital technologies.
- Updating educational content and methodological support based on a competency-based and digitally oriented approach.
- Integration of digital teaching tools and creative digital tasks into professional training.
- Promotion of self-reflection and objective self-assessment of professional competence.
- Practical orientation of learning tasks toward future professional activity.

Additionally, a specialized course focused on the formation of professional competence through digitalization was introduced for the experimental group. The control group followed the traditional curriculum without targeted digital pedagogical interventions.

Data collection methods

Data were collected using a combination of qualitative and quantitative methods:

- Questionnaires and surveys to assess motivational indicators and attitudes toward professional development.
- Testing to evaluate cognitive components of professional competence.
- Interviews and structured conversations to obtain qualitative insights into students' experiences.
- Self-assessment instruments to measure reflective and regulatory aspects of competence development.
- Pedagogical observation to monitor changes in professional behavior during the formative stage.

All instruments were aligned with the defined competence components and applied consistently at the ascertaining and control stages of the experiment.

Assessment procedure

Levels of professional competence formation were classified as high, medium, or low based on predefined criteria and indicators for each component. The assessment framework enabled a comprehensive evaluation of competence dynamics in both experimental and control groups.

Data analysis

Quantitative data were analyzed using descriptive and inferential statistics. To determine the statistical significance of differences between groups before and after the intervention, the Pearson's chi-square (χ^2) test was applied. The significance level was set at $p < 0.05$ to ensure an acceptable probability of error. Qualitative data obtained from interviews and observations were analyzed using content analysis, which allowed for the identification of recurring patterns and contextual interpretation of the results.

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Research validity and reliability

The validity of the study was ensured by aligning the research objectives, conceptual framework, methods, and assessment tools. Reliability was supported by the repeated application of diagnostic instruments, consistency of data collection procedures, and the use of both control and experimental groups. The mixed-methods approach enhanced the robustness of findings by enabling triangulation of quantitative and qualitative data.

Results and Discussion

Results

Professional competence of future art teachers was assessed according to three criteria: motivational, cognitive (knowledge), and creative–activity. Each criterion was evaluated at three levels (high, medium, low) based on predefined indicators.

Ascertaining stage

At the ascertaining stage, both the experimental group (EG, n = 60) and the control group (CG, n = 64) demonstrated comparable distributions of professional competence levels across all criteria. The results for the motivational criterion are presented in Tables 1 and 2, for the cognitive criterion in Tables 3 and 4, and for the creative–activity criterion in Tables 5 and 6.

Table 1.
State of formation of professional competence of EG respondents by motivational criterion (confirmatory stage of the experiment)

LEVELS	Value orientations	Communication	Self-esteem	Professional experience
High	22 %	24 %	24 %	24 %
Average	41 %	40 %	38 %	39 %
Low	37 %	36 %	38 %	37 %
TOTAL	100 %	100 %	100 %	100 %

Table 2.
State of formation of professional competence of CG respondents by motivational criterion (determinative stage of the experiment)

LEVELS	Value orientations	Communication	Self-esteem	Professional experience
High	20 %	21 %	21 %	22 %
Average	37 %	38 %	37 %	40 %
Low	43 %	41 %	42 %	38 %
TOTAL	100 %	100 %	100 %	100 %

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Table 3.
State of formation of professional competence of EG respondents by the knowledge criterion (the ascertaining stage of the experiment)

LEVELS	Professional knowledge	Cognitive interests	Self-regulation	Reflection
High	24 %	22 %	24 %	24 %
Average	38 %	39 %	44 %	43 %
Low	38 %	39 %	32 %	33 %
TOTAL	100 %	100 %	100 %	100 %

Table 4.
State of formation of professional competence of CG respondents by knowledge criterion (confirmatory stage of the experiment)

LEVELS	Professional knowledge	Cognitive interests	Self-regulation	Reflection
High	23 %	21 %	23 %	24 %
Average	37 %	38 %	45 %	40 %
Low	40 %	41 %	32 %	36 %
TOTAL	100 %	100 %	100 %	100 %

Table 5.
State of formation of professional competence of EG respondents by the creative criterion (the ascertaining stage of the experiment)

LEVELS	Professional communication skills	Empathy	Creativity
High	22 %	23 %	23 %
Average	38 %	40 %	39 %
Low	40 %	37 %	38 %
TOTAL	100 %	100 %	100 %

Table 6.
State of professional competence of the respondents of the CG by the creative criterion (asserting stage of the experiment)

LEVELS	Professional communication skills	Empathy	Creativity
High	20 %	21 %	22 %
Average	40 %	39 %	38 %
Low	40 %	40 %	40 %
TOTAL	100 %	100 %	100 %

Across all three criteria, the majority of respondents in both groups were concentrated at medium and low levels. High-level indicators did not exceed 22–24% in the EG and 20–22% in the CG. Pearson's chi-square test confirmed that no statistically significant differences between the EG and CG were observed at this stage ($\chi^2 < \chi^2_{crit}$, $p > 0.05$), indicating initial group homogeneity.

Formative and control stages

Following the implementation of digitally oriented pedagogical conditions in the EG, substantial changes were observed. According to the motivational criterion (Tables 7 and 8), the proportion of EG students with a high level of professional competence increased to 55%, while low-level indicators decreased to approximately 10%. In the CG, high-level indicators remained below 25%, and low-level indicators showed no meaningful reduction.

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Table 7.
State of formation of professional competence of respondents of the EG by the motivational criterion (formative stage of the experiment)

LEVELS	Value orientations	Communication	Self-esteem	Professional experience
High	55 %	55 %	55 %	55 %
Average	35 %	35 %	34 %	35 %
Low	10 %	10 %	11 %	10 %
TOTAL	100 %	100 %	100 %	100 %

Table 8.
State of formation of professional competence of CG respondents by motivational criterion (formative stage of the experiment)

LEVELS	Value orientations	Communication	Self-esteem	Professional experience
High	23 %	24 %	25 %	23 %
Average	41 %	42 %	41 %	43 %
Low	36 %	34 %	34 %	34 %
TOTAL	100 %	100 %	100 %	100 %

Similar dynamics were identified for the cognitive criterion (Tables 9 and 10). In the EG, high-level indicators increased to 54–57% across all cognitive components, whereas in the CG the distribution of competence levels remained close to the initial measurements.

Table 9.
State of formation of professional competence of EG respondents by knowledge criterion (formative stage of the experiment)

LEVELS	Professional knowledge	Cognitive interests	Self-regulation	Reflection
High	55 %	57 %	54 %	57 %
Average	35 %	34 %	36 %	33 %
Low	10 %	9 %	10 %	11 %
TOTAL	100 %	100 %	100	100 %

Table 10.
State of formation of professional competence of CG respondents by knowledge criterion (formative stage of the experiment)

LEVELS	Professional knowledge	Cognitive interests	Self-regulation	Reflection
High	24 %	25 %	23 %	25 %
Average	40 %	40 %	45 %	40 %
Low	36 %	35 %	32 %	35 %
TOTAL	100 %	100 %	100 %	100 %

The most pronounced changes were recorded for the creative–activity criterion (Tables 11 and 12). In the EG, high-level indicators increased to 57–58%, and low-level indicators declined to 7–9%. In contrast, the CG demonstrated minimal change, with high-level indicators not exceeding 24% and low-level indicators remaining above 30%.

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Table 11.
The state of formation of professional competence of EG respondents by the creative criterion (formative stage of the experiment)

LEVELS	Professional communication skills	Empathy	Creativity
High	57 %	58 %	58 %
Average	34 %	33 %	35 %
Low	9 %	9 %	7 %
TOTAL	100	100	100

Table 12.
State of formation of professional competence of CG respondents according to the creative criterion (formative stage of the experiment)

LEVELS	Professional communication skills	Empathy	Creativity
High	24 %	24 %	24 %
Average	44 %	43 %	44 %
Low	32 %	33 %	32 %
TOTAL	100 %	100 %	100 %

The statistical significance of the observed changes was verified using Pearson's chi-square (χ^2) test. In the EG, the calculated value ($\chi^2_{emp} = 32.45$, df = 2) exceeded the critical value at the 0.05 significance level ($\chi^2_{crit} = 7.815$), indicating statistically significant differences between the distributions before and after the intervention. In the CG, the calculated χ^2 value ($\chi^2_{emp} = 0.85$) did not reach the critical threshold ($p > 0.05$), confirming the absence of statistically significant changes under traditional training conditions.

Discussion

The results of the quasi-experimental study provide empirical evidence that the systematic integration of digital technologies within a competency-based pedagogical framework leads to measurable improvements in the professional competence of future art teachers.

The most substantial gains were observed in the creative–activity component. Pedagogically, this can be explained by the use of digital tools that expanded opportunities for creative expression, professional communication, and collaborative artistic activity. Digital platforms and interactive visual tools enabled students to engage in learning tasks that more closely resembled authentic professional situations, thereby strengthening creative and communicative competencies.

Positive dynamics in the motivational component indicate that digitally enriched learning environments contribute to the development of professional value orientations, self-confidence, and readiness for continuous professional development. These findings suggest that digitalization influences not only skill acquisition but also students' attitudes toward their future professional roles.

Improvements in the cognitive component reflect the role of digital tools combined with reflective and self-assessment practices in fostering deeper professional understanding, self-regulation, and reflection. This supports the view that digital competence functions as a structural element of professional competence rather than as an auxiliary skill.

The comparison between the EG and CG confirms that digitalization alone does not automatically improve learning outcomes. Statistically significant changes were

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observed only when digital technologies were embedded within clearly defined pedagogical conditions aligned with competence criteria and assessment procedures.

The results of the study provide clear empirical evidence that the proposed pedagogical conditions and the specialized course significantly enhanced the professional competence of future art teachers in a digitalized educational environment. The most substantial improvements were observed in the creative–activity and motivational components, suggesting that digitalization, when pedagogically structured, has a particularly strong impact on students' engagement, self-expression, and readiness for professional activity.

The pronounced growth in the creative–activity criterion can be explained by the integration of digital tools and creative tasks that expanded students' opportunities for artistic experimentation, communication, and collaborative work. This finding aligns with previous studies emphasizing the role of digital visual narratives and interactive media in fostering creative competence in art education (Gavaldon & McGarr, 2019; Gutiérrez-Cabello Barragán et al., 2021). Unlike earlier research that focused on isolated digital practices, the present study demonstrates the effectiveness of a systematic pedagogical framework that embeds digital tools within competency-oriented training (Na et al., 2024).

Improvements in the motivational component indicate that the digitalized learning environment and reflective practices contributed to stronger professional value orientations and increased awareness of the importance of continuous professional development. This result supports the conclusions of McDougald (2018), who highlight the role of integrative and socially oriented educational approaches in shaping professional identity, although the present study extends these insights specifically to pre-service art teachers within an experimental design (Zamperetti et al., 2017; Cárdenas-Pérez et al., 2016).

From a methodological perspective, the use of a quasi-experimental design, multidimensional competence assessment, and inferential statistical analysis strengthens the reliability and validity of the findings. The statistically significant differences between the EG and CG provide robust evidence that the observed changes were not incidental but resulted from the intentional implementation of pedagogical conditions and the specialized digital course.

Overall, the discussion confirms that digitalization alone does not automatically lead to improved professional competence. Rather, its educational potential is realized when digital tools are embedded within a coherent pedagogical strategy that integrates motivational, cognitive, and creative dimensions of professional training. These findings contribute to the existing literature by offering experimentally grounded evidence on how professional competence of future art teachers can be systematically developed in the context of digital transformation.

Conclusions

The results of the experimental study confirm the effectiveness of the proposed pedagogical conditions for the formation of professional competence of future teachers of art disciplines by means of digitalization. A comparative analysis of the indicators of the experimental and control groups showed statistically significant positive changes in the experimental group in all identified components of professional competence.

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The most pronounced improvement was recorded in the creative and activity component, which was manifested in the growth of the level of creativity, professional communication and empathy of future art teachers. This indicates the high potential of digital tools and creative digital tasks for the activation of artistic and pedagogical activity and the development of students' creative self-expression. Significant positive changes were also found in the motivational component, in particular in the formation of value orientations, professional motivation and conscious readiness for further professional development. The cognitive component demonstrated a steady increase in indicators of professional knowledge, self-regulation and reflection, which confirms the effectiveness of combining digitalization with methodically structured pedagogical support.

The central contribution of this study is an experimentally substantiated model of the formation of professional competence of future teachers of art disciplines, in which digital competence is considered not as an additional element, but as a structural component of professional training. Unlike previous studies, which mostly focused on individual digital tools, this work proves the effectiveness of the systematic implementation of digital pedagogical strategies within the framework of competency-based training.

However, the study has certain limitations. First, the sample included students from a limited number of higher education institutions, limiting the generalizability of the results to a wider population. Second, the diagnostic tools used, despite their validity, were partly based on self-assessment, which may affect the subjectivity of the results. Thirdly, the quasi-experimental design of the study did not provide for long-term monitoring of the stability of the formed competencies in the professional activities of graduates.

The practical consequences of the study are the possibility of using the developed pedagogical conditions and a special course in the system of training and advanced training of teachers of art disciplines. The results obtained can be used to update educational programs, develop digital pedagogical strategies, as well as to methodologically support the professional training of future teachers in the context of the digital transformation of education.

Prospects for further research are associated with expanding the sample, conducting longitudinal studies of the effectiveness of digital pedagogical strategies, as well as with an in-depth study of the training of art teachers to use innovative digital technologies (AR/VR, artificial intelligence, digital platforms for collaborative creativity) in professional activities. Of particular scientific interest is the study of the impact of digitalization on the formation of professional identity and pedagogical autonomy of teachers of art disciplines.

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Original Article

Impacto y prospectiva de la integración tecnológica en la didáctica de la matemática universitaria: Una revisión documental

Impact and prospects of technological integration in university mathematics teaching: A literature review

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Resumen

El objetivo principal de la presente investigación fue analizar la enseñanza de la matemática matizada desde las tecnologías en el nivel educativo. En lo metodológico estuvo imbuida en paradigma cualitativo, debido a la ausencia de so de recursos numéricos o estadísticos en el tratamiento de las informaciones, el tipo de investigación fue documental que permitieron consultar fuentes y estudios que dieron base epistemológica al estudio. En este sentido la técnica empleada fue la revisión bibliográfica explorando bases de datos como Scopus, Scielo, ERIH, EBSCO y google Scholar, además de tesis de maestría y doctorados en el área, en este sentido de 36 fuentes exploradas se seleccionaron 10 fuentes clave, con publicaciones no mayores a 8 años de data. En los resultados sobresalen que los postulados emitidos por los referentes y autores base del estudio, consolidan que la tecnología significa en la actualidad una herramienta de uso necesario. En las conclusiones la enseñanza de la matemática matizada desde las tecnologías en el nivel educativo se constituye en la coyuntura contemporánea en una posibilidad que brinda a docentes e investigadores, herramientas de uso para explorar nuevas vías.

Palabras clave: Educación, formación, enseñanza de la matemática, instituciones educativas, tecnologías educativas.

Abstract

The main objective of this research was to analyze the teaching of mathematics enriched with technologies at the educational level. Methodologically, it was immersed in a qualitative paradigm, due to the absence of numerical or statistical resources in the treatment of the information. The type of research was documental, which allowed consulting sources and studies that provided the epistemological basis for the study. In this regard, the technique used was a literature review, exploring databases such as Scopus, Scielo, ERIH, EBSCO, and Google Scholar, in addition to master's and doctoral theses in the field. From the 36 sources explored, 10 key sources were selected, with publications not older than 8 years. The results highlight that the propositions put forward by the references and foundational authors of the study establish that technology nowadays represents a necessary tool. In the conclusions, the teaching of mathematics, enriched by technology at the educational level, constitutes in the contemporary context a possibility that provides teachers and researchers with tools to explore new avenues.

Keywords: Education, training, mathematics teaching, educational institutions, educational technologies.

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Introducción

La educación en el presente milenio ha experimentado retos que devienen de los vertiginosos avances de las ciencias y las tecnologías, cuya propensión no es fácil de precisar, lo que significa que los estudiantes en todos los niveles, en particular los universitarios, deban ejecutar tareas de accesibilidad de manera diaria y continua en el propósito de explorar volúmenes considerados de informaciones, desarrollando de manera temprana los estadios cognitivos y afectivos por una coyuntura que los imbuye de forma irremisible. Se trata de un escenario cuyas mutaciones son verdaderamente excepcionales (Quishpe, 2023). La realidad actual indica que "La falta de comprensión y aplicación de estos conceptos matemáticos en el aula indica la urgencia de buscar herramientas tecnológicas que faciliten dicho aprendizaje". (Carrero Vargas, 2026, p. 17)

Uno de los beneficios de estas circunstancias es que tanto los docentes como los estudiantes que explorar la tendencia de las tecnologías en los intercambios de saberes de contenidos matemáticos, es que se evidencia un desarrollo tanto de las habilidades numéricas, realización de cálculos de manera rápida y el desarrollo progresivo y consistente de los procesos de razonamiento lógico (Condori, 2020; Parada Carreño et al., 2026), lo que implica de manera subyacente que tanto las metódicas como los recursos pedagógicos han sufrido adaptaciones para un uso efectivo y practico de los mismos, con el propósito de que sirvan de constructo para las tareas de autoaprendizaje, que es una necesidad que emerge por los contactos que se establecen con los equipos tecnológicos de uso cotidiano (Estrada & Bennasar García, 2021; Zenteno et al., 2020).

En este sentido, "Para aprovechar al máximo el potencial de la tecnología en la enseñanza de la matemática, es crucial invertir en la formación docente y abordar la brecha digital. Se necesita una planificación cuidadosa para equilibrar la tecnología…". (Roche Cordero et al., 2024, p. 193), lo que implica brindar oportunidades a los sujetos de aprendizaje al aprendizaje de la matemática.

Por tanto, al desarrollar contenidos en el área de la matemática para consustancias la enseñanza y el aprendizaje, la asunción de los recursos tecnológicos es una especie de corolario en las actividades de aula en las diversas universidades, esto para la comprensión y aprehensión de saberes intrínsecos en esta disciplina, y para una construcción progresiva de sus contenidos, que de manera inminente decantan de los arqueos y búsquedas de datos e informaciones, que puedan servir de base para la solución de problemas puntuales y cotidianos. La era digital hoy marca un rumbo que se describe como una experiencia inédita e irrepetible, donde los jóvenes universitarios exploran de manera dedicada a partir de las distintas plataformas que han creado un submundo particular. En el caso de la matemática, su enseñanza tiene ventajas que se conjugan con el desarrollo cognitivo, el desarrollo de un pensamiento reflexivo y la comprensión de objetos y procedimientos intangibles. "Desde un ángulo general, la investigación educativa actual se enfoca en mejorar los métodos de enseñanza y aprendizaje, destacando la importancia de metodologías activas, inclusivas y que integren la tecnología". (Mejía Coello et al., 2026, p. 121).

La integración y adopción de la tecnología en los intercambios de saberes de la matemática a nivel universitario se ha constituido en una praxis que se concibe desde dos aristas o perspectivas: como constructo axiomático que combina el razonamiento lógico y la demostración, y en segundo término como herramienta necesaria para el advenimiento y consolidación de los proyectos tecnológicos en la sociedad y en la universidad (Mora, 2023). Es decir, en el devenir de la enseñanza

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de la matemática encausada por los elementos de la tecnología, se erigen con una "una disposición para actuar apropiadamente en respuesta a todo tipo de desafíos matemáticos relacionados con diversas situaciones". (Niss & Højgaard, 2019, p. 12), lo que implica que si los procesos se realizan hoy en día para tratar temas específicos sin la tecnología, puede ser no auspicioso, pues "… en la disciplina de Educación Matemática que muchas se encuentran en aislamiento, en el sentido, que se utilizan de forma muy particular en determinadas investigaciones y que la noción de competencia matemática no es la excepción". (Aké & Páez, 2024, p. 247).

Las tecnologías por tanto, han motivado de manera significativa a desarrollar protocolos pedagógicos de avanzada para optimizar tanto las interacciones como la personalización de los aprendizajes de los estudiantes universitarios en el área de matemática, utilizando para ello equipos y plataformas de simulación, visualizaciones previas de ejecuciones, realización de gráficas de funciones, así como la realización de cálculos avanzados Céspedes Rojas et al., 2026; Niss & Jankvist, 2022). En ese sentido el objetivo principal de la presente investigación fue analizar la enseñanza de la matemática matizada desde las tecnologías en el nivel universitario.

A continuación, se presentan los referentes teóricos, seguidos del método documental empleado, los hallazgos organizados en tablas y la discusión final:

Referentes teóricos

La enseñanza de las matemáticas y la tecnología se fundamenta en diversas teorías o principios pedagógicos, que se constituyen en la base epistemológica para el establecimiento de las interconexiones socioculturales, en este sentido se asume el constructivismo Bruner (1983) y Piaget (1971), ya que en el proceso de enseñar matemáticas desde la tecnología se requiere de la participación activa de los sujetos de aprendizaje, en tanto se construye desde sus aprestos. De acuerdo a estos preceptos los enfoques STEM son herramientas tecnológicas cuya aplicación permite visualizar el tratamiento y resolución de problemas no tangibles o abstractos.

Dos conceptos fundamentales apoyan la idea del conocimiento construido. El primero es que los estudiantes utilizan sus conocimientos previos para construir nuevas comprensiones. Muchos académicos coinciden en que los estudiantes adquieren un conocimiento sustancial antes de comenzar la educación formal. Con este conocimiento previo o experiencia previa, los aprendices modifican su conocimiento existente a través de nuevas experiencias de aprendizaje, y en el caso de las matemáticas, se constituye en una fortaleza a considerar en los procesos didácticos y los intercambios que se ejecutan a través de la tecnología (Landívar De la Torre et al., 2025). El segundo concepto es que el aprendizaje es un proceso activo y no pasivo. Aquí, el aprendiz evalúa su conocimiento a la luz de lo que encuentra en el nuevo entorno de aprendizaje. La enseñanza universitaria de las matemáticas enfrenta una problemática marcada por el bajo rendimiento estudiantil, la falta de metodologías innovadoras y la débil articulación entre teoría y práctica (Moreno Llacza, 2025, p. 1672).

"Ante la innegable presencia, cada vez más fuerte, de las tecnologías digitales en las aulas de clase de matemáticas, las cuales imponen desafíos a los profesores que los obligan a repensar sus prácticas de enseñanza con estos nuevos recursos". (Pérez Medina 2014, p. 130). Esta postura teórica y reflexiva da cuenta de que las tecnologías en el ámbito de la matemática, pueden matizar los procesos y las

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vinculaciones pedagógicas que permitan una mejor aprehensión de los saberes en esta área tan importante.

Método

En el desarrollo de la presente investigación se asumió el paradigma cualitativo, en la condición del no uso de referentes estadísticos ni numéricos para los análisis respectivos. La visión cualitativa de los hechos permite cubrir un espectro importante que permiten dar cuenta de la fenomenología a través de las informaciones de interés indagatorio (Rojas-Gutiérrez, 2022). El tipo de investigación fue documental empleando en procedimientos para procesar la información los arqueos subsecuentes. Los documentos son una fuente importante de informaciones que dan dirección a los elementos analíticos (Paredes Morán et al., 2025).

La técnica empleada a los efectos de búsquedas y sistematización de informaciones fue la revisión bibliográfica escudriñando estudios, revistas e investigaciones sobre el uso de las tecnologías en los procesos de enseñanza aprendizaje de la Matemática. La revisión bibliográfica tiene la facultad de organizar los referentes y teorías, que los investigadores van analizando a fin de concretar las bases que dan sentido y coherencia al estudio (Tapia Chacón et al., 2026).

En este caso los descriptores empleados para las búsquedas fueron: "Mathematics" AND "Educational Technology", Mathematics education, ICT, E-learning y educational technology, que dieron la base necesaria para fundamentar los arqueos realizados.

La investigación documental es un aporte importante a los diferentes estudios dada la versatilidad en los análisis y resúmenes que emergen de las diferentes fuentes (Zambrano Rodríguez et al., 2025), en este orden de ideas se revisaron bases de datos de publicaciones indexadas, entre ellas Scopus, Scielo, ERIH, EBSCO y google Scholar, además de tesis de maestría y doctorados en el área.
A tales efectos se ejecutaron las siguientes fases;

Fase 1: La exploración inicial en las bases descritas, permitieron la consulta de 36 referentes en el área de interés investigativo, de éstas se seleccionaron 10 que respondían a las características específicas del estudio.

Fase 2: En el criterio de inclusión se consideraron obras cuya data no superaran los 8 años de publicación.

Fase 3: Las temáticas escogidas estuvieron direccionadas a:

- Las tecnologías en matemáticas como herramienta auxiliar pedagógica.
- Estudios de los impactos de las tecnologías en la enseñanza de la matemática.
- Recursos y herramientas para la enseñanza de la matemática en la universidad.
- Procesos de capacitación de docentes en el área de la matemática, en el uso de las tecnologías.

Fase 4: Compilación y organización de los hallazgos clasificados por autores, año, y descripción temática.

Esta esquematización facilitó las congruencias de búsquedas y de filtración de documentos e informaciones acerca de la enseñanza de la matemática matizada por las tecnologías, en los diferentes niveles y modalidades del sistema educativo,

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por tanto, permitieron expresar de manera clara y resumida los hallazgos que se presentan.

Resultados y discusión

Dentro de los aportes bibliográficos que se encontraron y que de acuerdo la previsión metodológica ya expuestas, se decantó 10 investigaciones que se expresan en la tabla 1, y que dan cuenta de la actualidad de la temática, así como de la importancia en diversas esferas mundiales.

El interés en este sentido es que los arqueos realizados, permitan dar cuanta de un tema que impacta la urbe educativa y que cada investigador debe estar en sintonía con tales avances, para estudiarlos y tratarlos de manera científica. En virtud de ello los resultados son los siguientes:

Tabla 1.
Referentes teóricos sobre la enseñanza de la matemática matizada por la tecnología

Autores / Año	Documento / Título	Descripción temática
Bendoiro Pérez, & Díaz Tejera (2024)	Artículo / Retos de la Didáctica de la Matemática con el empleo de las tecnologías	*Las insuficientes competencias digitales que poseen los docentes pudieran estar dadas, entre otros aspectos, por la brecha generacional existente entre los llamados nativos y emigrantes digitales. En Cuba, por ejemplo, existen muchos docentes que pertenecen a una generación nacida en las últimas décadas del siglo XX, lo que los hace emigrantes digitales. Ellos vivieron y se formaron como profesores sin tener acceso a las tecnologías y a la información con las facilidades que brinda la era actual. De cierta manera han visto surgir estas tecnologías y han tenido que adaptarse a ellas tanto en el ámbito personal como profesional.* *Estas características implican que, aunque pueden llegar a utilizarlas las TIC con la misma habilidad que los nativos digitales, han tenido que esforzarse para dominarlas y mucho más para incorporarlas a su labor en las aulas. Para lograrlo requieren de tiempo para su preparación, en primer lugar, para dominar la tecnología y en segundo lugar para concebir las actividades docentes donde las van a emplear. Esto unido a la infraestructura que existe en el país con respecto a la informatización, hace que no todos posean las competencias suficientes para manejar las tecnologías en el ámbito profesional, lo que influye también en la actitud que asumen ante la necesidad de utilizarlas en sus clases* (Bendoiro Pérez & Díaz Tejera, 2024, p. 14).
Alvites (2017).	Artículo / Herramientas TIC en el aprendizaje en el área de Matemática: Caso Escuela PopUp, Piura-Perú	*… las TIC contribuyen a la construcción de conocimiento por facilitar el acceso a información e incrementar la interactividad y conectividad, que permiten la mediación pedagógica en los contenidos de los cursos.* *Ello conlleva a la promoción del aprendizaje mediante el uso de una variedad de herramientas tecnológicas, el desarrollo de las inteligencias múltiples y los estilos de aprendizaje* (Alvites, 2017, p. 20).
Sánchez-Lima et al., (2026).	Artículo / Investigation of mastery math lab impact on undergraduate college algebra student success.	*El estudio se orienta a explorar las demandas que se suscitan en el mercado laboral en las áreas de ciencia, tecnología, ingeniería y matemáticas, destacando que ha existido una disminución importante en las opciones de estudios en estas disciplinas o campos de saber, explicando las*

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		limitaciones sobre los procesos didácticos y las metódicas para enseñar y capacitar en áreas duras (Sánchez-Lima et al., 2026, p. 67).
Arroyo-Arroyo, & Yánez-Rodríguez (2020).	Artículo /Propuesta de herramientas TIC para facilitar el proceso enseñanza – aprendizaje de la matemática	*Las herramientas TIC facilitan el proceso enseñanza – aprendizaje de la matemática, mediante recursos que proporcionan una real experiencia en los estudiantes, quienes a través de la experimentación matemática se vuelven protagonistas de su proceso de aprendizaje* (Arroyo-Arroyo, & Yánez-Rodríguez, 2020, p. 575).
Alcázar Solís, González Retana, Sánchez Castro & Sequeira Mendoza (2023).	Tesis de grado / Uso de las tecnologías digitales en la enseñanza de la matemática en el área de números y su influencia en el desarrollo cognitivo del estudiantado de quinto grado de la escuela Excelencia Juan Santamaría de la Dirección Regional de Sarapiquí, durante el tercer trimestre del curso lectivo 2022	*La enseñanza de las matemáticas evolucionó a través de los años. Hacer matemáticas implica más que la simple manipulación de números o símbolos, lleva a resolver problemas del quehacer diario. (…) Cabe mencionar que, para que este proceso sea efectivo es necesario el asesoramiento, capacitación y la autocapacitación constante por parte del docente. Al llegar a este punto, es importante comprender que los docentes deberán comprometerse consigo mismo y el estudiantado, para lograr implementar nuevas metodologías que ayuden al estudiantado a la comprensión de los contenidos desarrollados* (Alcázar Solís et al., 2023, p. 9).
George (2019).	Articulo / Reducción de obstáculos de aprendizaje en matemáticas con el uso de las TIC	*Los resultados de la investigación realizada evidencian que los estudiantes suelen utilizar las tecnologías con el fin de hacer correcciones conceptuales y procedimentales de aquellos conocimientos matemáticos que de alguna forma representan obstáculos para la generación de nuevos conocimientos, lo anterior permite despertar el interés por el aprendizaje, es decir, utilizan los medios educativos como un instrumento de apoyo para el estudio.* *En cada una de las categorías analizadas: anclaje de conocimientos previos, interpretación del saber y percepciones acerca de los docentes usuarios de las TIC, se encontró que existe cierta afinidad por agilizar el proceso de enseñanza-aprendizaje utilizando herramientas tecnológicas, de igual forma se observó que si bien las tecnologías han posibilitado un cambio en la educación de los estudiantes de bachillerato, son los docentes quienes han aprovechado las propiedades innovadoras de estas herramientas* (George, 2019, s/p).
Quintero & Jerez (2019).	Artículo / Las Tic para la Enseñanza de la Matemática en Educación Media General	*La matemática es una asignatura primordial dentro del currículo educativo, razón por la cual los docentes deben emplear estrategias que permitan mejorar el aprendizaje e integrar al mismo tiempo los recursos que aportan las TIC, incentivando a los estudiantes a interactuar con sus compañeros, con los docentes y entre docentes, e igualmente, debe trabajar en forma colaborativa y cooperativa para buscar nuevas competencias y habilidades y contribuir con la formación integral que exige. El docente al usar las TIC, debe tener unas habilidades adecuadas hacia ellas, pues el tener conocimientos sobre su uso es lo que genera el cambio de estrategias pedagógicas utilizándose esta herramienta como apoyo en el proceso de enseñanza de la matemática.* *En tal sentido, actualmente se habla de que se tiene una sociedad de la información sometida a vertiginosos cambios y adelantos, que ocurren en* todos los aspectos de la vida o sociedad existente. *Por ende, el surgimiento de las TIC, se causa la necesidad de promover sus prácticas en los procesos de enseñanza y aprendizaje, debido a que a la educación ha tocado un nuevo reto entre sus metas, como es el de preparar a las nuevas y actuales*

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		generaciones e incorporar las tecnologías de manera activa en consonancia con los tiempos actuales, porque las TIC están presente de múltiples formas, y además, les corresponde emprender una acción sistemática a la alfabetización digital de los estudiantes y docentes, por lo que exige ir más allá de la simple instalación de una aula de informática en la escuela (Quintero & Jerez, 2019, s/p).
Arteaga Valdés (2019).	Artículo /El Geogebra: una herramienta tecnológica para aprender Matemática en la Secundaria Básica haciendo matemática	*La utilización de las competencias y conocimientos tecnológicos ha ocupado un lugar relevante en el sistema de enseñanza, tanto para profesores como estudiantes, pues estos se consideran como elementos mediadores…* (Arteaga Valdés et al., 2019, p. 103).
Sánchez-Bracamontes, (2023).	Artículo /Las competencias matemáticas y el empleo de las tecnologías en estudiantes de bachillerato en México	*El uso de dispositivos móviles les genera un cambio de paradigma ante el proceso tradicionalista habitual dentro del Colegio de Bachilleres. El análisis proporcionado por algunos estudiantes resalta un límite que debe existir entre mobile-learning y el aprendizaje tradicionalista, "la aplicación debe ser usada en algunas ocasiones, para evitar que haga todo por nosotros". Lo cual permite precisar que los estudiantes son conscientes, sobre la necesidad de desarrollar de manera individual competencias matemáticas* (Sánchez-Bracamontes, 2023, p. 35).
Chila Ortiz et al. (2023).	ERCA y ABP: enfoques educativos que fomentan el desarrollo del pensamiento lógico con estrategias innovadoras en la enseñanza de matemática.	*"La mayor parte de los docentes de matemáticas emplean un método tradicional y rutinario en su instrucción,…".* (Chila Ortiz et al., 2023, p. 8)*, esto significa qu4 una didáctica en este campo disciplinario reclama un ajuste en las concepciones y formas de implementación.*

Fuente: Elaboración propia, 2026.

La educación matemática dentro del contexto formativo escolar, viene a cumplir una finalidad que establece principios y bases que trascienden el quehacer cotidiano. Es en esencia la posibilidad de una formación que permita fortalecer los mecanismos pedagógicos a través del uso de los recursos que permitan un intercambio de temáticas, basadas en la actualidad y en las necesidades coyunturales del presente milenio.

De acuerdo a los resultados presentados se pueden establecer los principios que rigen los acontecimientos en las diversas instituciones, orientando de manera precisa las vocaciones a través del uso de herramientas que revitalicen el acervo estudiantil y la labor docentes. "La educación como proceso humano de formación continua, ha sido la piedra angular de los grandes acontecimientos de la humanidad". (Bennasar-García & Estrada, 2021, p. 435), y en ello la matemática ha tenido un impulso determinante en la consolidación de los principios tecnológicos.

A decir de los contenidos de la matemática, los escenarios áulicos son el primer elemento que se explora, sin embargo la coyuntura actual demanda el uso de la tecnología de manera continua, porque existe otra cotidianidad y otros escenarios. De tal manera que estas realidades mostradas en la tabla 1, hablan de la preeminencia de las plataformas digitales para establecer comunicación entre los profesores y los estudiantes, ejecutando tareas con resultados inmediatos, que es uno de los beneficios de estas circunstancias que se experimenta en redes. "La integración de tecnologías en el ámbito educativo ha emergido como un elemento transformador en la enseñanza y el aprendizaje de las matemáticas en la educación

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universitaria". (Coy García et al., 2024, p. 167), y en ello las tecnologías han sido un soporte fundamental.

Otro elemento que se destaca en los hallazgos es la necesidad perentoria de colocar a las instituciones educativas en el carril de la tecnología, que en el caso de la matemática, se han convertido en una herramienta vital para la resolución de problemas y para el tratamiento y manejo de volúmenes de informaciones, que requieren de uso. En este orden deviene lo que se ha denominado la condición de eticidad en tales procesos, sin excluir las fenomenologías áulicas que marca el quehacer educativo, pues son muy importantes "…los efectos que estas tienen en los estudiantes, reconociendo que sus decisiones didácticas estaban inspiradas en sus propias prácticas como aprendices de las matemáticas, en su experiencia docente, en estereotipos de la clase de matemáticas,…". (Clavijo-Riveros, 2024, p. 3).

Las nuevas concepciones de la educación matemática deben abrir un abanico didáctico que involucre o combine la práctica tradicional "de la tiza y el pizarrón", cono los elementos tecnológicos actuales (Bohórquez, 2020), y esta es una tendencia que se enmarca en la realidad coyuntural actual.

El proceso de enseñanza y aprendizaje de la matemática haciendo uso de los recursos étnico-digitales, donde los estudiantes interactúan en forma directa con su entorno social, cultural, físico y tecnológico, coadyuvan a la implementación de un proceso educativo con equidad y pertinencia, conduciendo al estudiante a desarrollar su pensamiento numérico, algebraico y geométrico de manera activa, a través de la manipulación de objetos concretos de su entorno y de los recursos digitales; la misma que mejora su nivel de motivación para el estudio, habilidad para resolver problemas, elaboración y recreación de conceptos, el modelamiento, la resolución de problemas y el proceso de comunicación matemática; fortaleciendo su competencia matemática, como muestran los resultados de la lista de cotejo. (Ramón & Vilchez, 2019, p. 267).

Por tanto reimaginar la educación matemática atizada por las tecnologías, es precisar la necesidad de incorporarse al uso de los grandes programas y redes que están marcando una pauta importante en la actualidad, y en consecuencia las instituciones deben establecer las condiciones para tales fines (Aké & Olvera-Martínez, 2022; Radford, 2021).

Conclusiones

La enseñanza de la matemática en la actualidad presenta retos abiertos y consolidados hacia la tecnología, la cual debe asumirse con la responsabilidad pedagógica del caso para no correr el riesgo de quedar rezada como disciplina científica.

La enseñanza de la matemática matizada desde las tecnologías en el nivel educativo se constituye en la coyuntura contemporánea en una posibilidad que brinda a docentes e investigadores, herramientas de uso para explorar nuevas vías y escenarios indagatorios, que posibiliten la resolución de problemas y el establecimiento de normas pedagógicas afines con tales principios.

Una de las ventajas pedagógicas que se adquieren con el uso de la tecnología en los intercambios de saberes de la matemática es la interactividad entre los actores del proceso, y esto dinamiza de manera notable el tratamiento de temas y escenarios que de manera prospectiva se puedan abordar.

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La novedad de las tecnologías para la práctica de la enseñanza de la matemática, facilita de manera concreta la gestión de los docentes y desempeño de los estudiantes, que utilizada de manera adecuada, puede producir resultados plausibles a mediano y corto plazo.

Limitaciones del estudio

Por tratarse de una investigación cualitativa, las aproximaciones tienden a cubrir el espectro fenomenológico de lo que se indaga, y esto puede acarrear algunos sesgos interpretativos involuntarios. Además, la muestra seleccionada de 10 fuentes remitió un análisis que puede impactar en los diseños curriculares o en la visión de la didáctica matemática, desde una cultura digital que amerita seguir explorando y profundizando su esencia, lo que no desmerita en modo alguno, las ideas y conclusiones que se expresan.

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Original Article

Digital technologies for the development of research competence in higher education students

Tecnologías digitales para el desarrollo de la competencia investigativa en estudiantes de educación superior

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Abstract

The study describes the content, components, and specific features of research competence. The importance of the problem of the modern scientific space of human existence is shown in compliance with academic integrity. The roles of virtual reality technologies, artificial intelligence, and blockchain in developing students' research competence are clarified, and the role of the pan-European platform for higher digital education for students is demonstrated. The significance of independent work by higher education applicants in developing research competence and participating in academic mobility programs through the use of digital technologies is demonstrated. In the course of the study, a technology for the formation of research competence in future specialists through the use of digital technologies, which is necessary for modern professional human activity, was developed and substantiated, along with pedagogical conditions and a special course.

Keywords: research competence, future specialists, use of digital technologies, virtual reality, artificial intelligence.

Resumen

El estudio describe el contenido, los componentes y las características específicas de la competencia investigadora. Se demuestra la importancia del problema del espacio científico moderno de la existencia humana en el cumplimiento de la integridad académica. Se aclara el papel de las tecnologías de realidad virtual, la inteligencia artificial y la cadena de bloques en el desarrollo de la competencia investigadora de los estudiantes, y se demuestra el papel de la plataforma paneuropea para la educación superior digital para estudiantes. Se demuestra la importancia del trabajo independiente de los solicitantes de educación superior en el desarrollo de la competencia investigadora y la participación en programas de movilidad académica mediante el uso de tecnologías digitales. En el curso del estudio, se desarrolló y fundamentó una tecnología para la formación de la competencia investigadora en futuros especialistas mediante el uso de tecnologías digitales, necesaria para la actividad profesional humana moderna, junto con las condiciones pedagógicas y un curso especial.

Palabras clave: competencia investigadora, futuros especialistas, uso de tecnologías digitales, realidad virtual, inteligencia artificial.

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Introduction

The development of modern society is characterized by high dynamics of modernization, covering all spheres of human activity and life. In the context of digital transformation and rapid technological progress, interest in scientific research is constantly increasing, aimed at solving problems that arise from the ongoing introduction of innovations across all spheres of society. Every year, the scientific literature is replenished with a large number of significant studies across various fields. Therefore, in the context of modern challenges, individual areas of scientific research need to be revised. The digital direction opens up entirely new areas of research that align with contemporary trends in educational development.

The development of research competence in specialists deserves special attention because it fosters a critical approach and analytical thinking, enabling them to generate innovative solutions and solve unique problems. One aspect of solving problems using digital technologies to develop research competence in each person is a new look at the education and professional activities of future specialists.

In today's conditions, the level of requirements for an individual's research competence is increasing, as there is constant entry into the market of digitalization services and technologies, and the development of artificial intelligence by future specialists. Inseparable from the digitalization of education and professional activities of a person are adherence to the principles, norms, and rules of academic integrity, the ability to critically evaluate information, the culture of business communication, the ability to find primary sources and reliable facts, etc. Therefore, the formation of research competence in future specialists in the conditions of digitalization is a process of developing an integrative purposeful quality of the individual, which provides experience in scientific and research activities, provides the ability to combine motivation, skills, abilities, knowledge, values, and professional interests, to develop the capabilities of the individual in the field of education, solve issues of using the latest digital technologies, improve skills for improving professional activities, conduct research, and provide conditions for professional continuous self-development throughout life (Rodríguez et al., 2024).

Research competence of future specialists focuses on the properties and professionally essential qualities of the individual through the use of digital technologies, as manifested in the ability and willingness to conduct research. The mentioned competence includes the researcher's experience, skills, abilities, knowledge, personal traits and value orientations; it is manifested in programming the course of one's own research activities, the ability to determine the goal, objectives of the research, subject, object and vision of the essence of the problem, using a creative approach, evaluating results and analyzing research activities, etc. No less important for future specialists are the ability to apply research competence to analyze the results of research activities, the ability to present one's own achievements using digital technologies, and the ability to formulate conclusions. Research competence of a future specialist is an integral part of professional and general education.

Literature Review

Recent research demonstrates a growing convergence around the importance of digital competence and research competence as core outcomes of higher education in the context of digital transformation. However, the literature also reveals conceptual ambiguities, methodological differences, and gaps between general

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frameworks of digital competence and concrete pedagogical technologies for developing research competence.

Gisbert Cervera & Caena (2022) treat digital literacy and digital competence as largely synonymous, emphasizing their systemic role in teacher education and professional development. While this broad conceptualization supports the integration of digital tools into higher education, it does not sufficiently differentiate how digital competence specifically contributes to the formation of research competence. In contrast, Skakun (2021) grounds digital competence in national curricular frameworks and highlights its practical relevance for professional training. Although both approaches stress the necessity of digital skills, a tension emerges between generalized models of digital competence and the need for discipline-specific, research-oriented applications, which are central to the present study.

Beaulieu et al. (2024) extend the discussion by focusing on collaborative research competencies, particularly reflective and boundary-spanning competences. Their work highlights the importance of researchers' ability to move between academic and practitioner contexts. This perspective converges with the present study in recognizing research competence as a dynamic, practice-oriented construct. However, their analysis is primarily situated within collaborative and organizational research settings and provides limited guidance on how such competencies can be systematically formed through pedagogical technologies in higher education curricula.

Empirical intervention studies further demonstrate the effectiveness of integrating pedagogical strategies with digital tools to enhance research competence. Paucar-Curasma et al. (2025) show that combining Pólya's problem-solving framework with a STEM educational kit significantly improves students' analytical, planning, and critical thinking skills. Similarly, Winchez Aylas & Bejarano Alvarez (2025), in their systematic review, identify flipped learning, Lean startup approaches, and research workshops as effective strategies for developing both technical and transversal research skills. These studies converge in emphasizing active, problem-based, and technology-supported learning. Nevertheless, they primarily focus on isolated methods rather than on a holistic pedagogical technology that integrates motivation, cognition, and technological components, as proposed in the current research.

Espinoza-Montes et al. (2025) draw attention to assessment practices in research competence development, noting a predominance of summative assessments and a relative underuse of formative approaches. This finding highlights a critical gap between the recognized need for continuous competence development and the prevailing evaluation practices in higher education. The present study addresses this gap by embedding assessment within a comprehensive pedagogical technology that aligns formative and summative dimensions with the staged development of research competence.

Overall, the literature demonstrates broad agreement on the importance of digital technologies for supporting research competence. At the same time, important gaps remain: (1) limited integration of digital competence frameworks with concrete pedagogical technologies for research competence formation; (2) insufficient alignment between instructional strategies and assessment models; and (3) a lack of holistic models that systematically combine motivational, cognitive, and technological components. The present study builds on these convergences while

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addressing these gaps by proposing and empirically validating an integrated pedagogical technology for the formation of research competence through the use of digital technologies.

Research purpose. Formation of research competence of future specialists through the use of digital technologies.

Methodology

Research Design

This study employed a quasi-experimental research design with control (CG) and experimental groups (EG) to examine the effectiveness of an innovative pedagogical technology for the formation of research competence in future specialists through the use of digital technologies. The design included an ascertaining (pre-test) stage and a formative (post-test) stage, enabling the assessment of changes in research competence over time and comparison between groups.

Participants

The participants were 184 higher education students enrolled in professional training programs at higher education institutions. The sample was divided into an experimental group (EG) and a control group (CG). At the ascertaining stage, 132 students participated in the diagnostic procedures to determine baseline levels of research competence. Statistical analysis using the Kolmogorov–Smirnov test confirmed that there were no statistically significant differences between the EG and CG at baseline ($p > 0.05$), indicating group equivalence prior to the intervention.

Participation was voluntary, and all respondents provided informed consent. The study was conducted in accordance with institutional ethical standards and principles of academic integrity.

Intervention: Pedagogical Technology

The experimental group was exposed to an innovative pedagogical technology designed to develop research competence through the systematic use of digital technologies. The technology was grounded in competence-based, systemic, personality-oriented, axiological, situational, and synergistic approaches.

The intervention included:

- Implementation of developed pedagogical conditions (digitalization of educational components; organization of students' research activities using web technologies; dynamic updating of training content);
- Integration of an author's special course focused on research competence development;
- Use of interactive forms of instruction (multimedia lectures, visualization lectures, webinars, trainings, master classes, round tables, blended learning, and virtual consultations);
- Application of active and interactive methods (problem-based learning, flipped learning, case method, brainstorming, web-quests, interactive portfolios, and game design);
- Systematic use of digital tools for visualization, collaboration, assessment, and research organization.

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The control group followed the standard curriculum without the implementation of the proposed pedagogical technology.

Instruments and Measures

Research competence was operationalized through three components: motivational, cognitive (gnostic), and technological. For each component, specific indicators were defined in accordance with the conceptual framework of the study.

Data were collected using a комплексний діагностичний інструментарій, which included:

- Structured questionnaires to assess motivational aspects;
- Knowledge tests to measure cognitive (gnostic) components;
- Performance-based tasks and expert evaluations to assess technological and activity-related components of research competence.

Each component was evaluated across three levels of formation: low, average, and high. The instruments were reviewed by subject-matter experts to ensure content validity.

Procedure

The study was conducted in three main stages:

1. **Ascertaining stage (pre-test):** Baseline measurement of students' research competence in both EG and CG using the selected instruments.
2. **Formative stage (intervention):** Implementation of the pedagogical technology in the EG over the course of the academic period, while the CG continued with traditional instructional practices.
3. **Control stage (post-test):** Re-assessment of research competence in both groups using the same instruments to determine changes attributable to the intervention.

Data Analysis

Quantitative and qualitative data analyses were employed. Descriptive statistics were used to determine the distribution of students across levels of research competence. To test group equivalence and the effectiveness of the intervention, the Kolmogorov–Smirnov λ-test was applied to compare empirical distributions between the EG and CG at both pre-test and post-test stages.

The level of statistical significance was set at $p \leq 0.05$. The null hypothesis (H0) stated that there were no statistically significant differences between the distributions of research competence levels in the EG and CG, while the alternative hypothesis (H1) stated that significant differences existed as a result of the intervention.

Ethical Considerations

The study adhered to ethical standards for educational research. Participation was voluntary, anonymity and confidentiality of respondents were ensured, and data were used exclusively for research purposes. The study complied with institutional requirements and principles of academic integrity.

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Results and Discussion

Content of the concept, components, and specific features of research competence. An important problem in modern scientific space for human existence is the observance of academic integrity.

Research competence is a personal-professional and integrated quality of a specialist that reflects the level of mastery of scientific research methodology, motivation for scientific search, and the personally significant qualities of the researcher: the ability to engage in innovative and creative activity and to think innovatively.

Important components of the research competence of future specialists include the ability to work with large amounts of data, adapt to a digital environment, and apply modern digital technologies in scientific activities. Active use of digital resources is widespread across all spheres of society, and the educational and scientific fields are no exception. Educational realities have flooded the digital space with new means of information processing and search, and digital programs and gadgets have become assistants and substitutes in performing the main stages of research work (Peters et al., 2022).

Research competence of a specialist involves the implementation of clear stages of activity, which can be equated with the ability to search for solutions with unknown outcomes, to answer research tasks, and to engage in creative exercises. The research competence of a specialist is an integrative, holistic characteristic of the personality of a specialist, which for professional activity in order to obtain new knowledge combines the means of research activity, skills, knowledge at the level of technology, value attitude, personal qualities, which are manifested in the ability and willingness to carry out research activities of a higher school student by solving educational problems, applying methods of scientific knowledge, building an educational digital process (Padilla-Hernández et al., 2020).

The main goal of a specialist's research activity is high-quality professional training through self-realization and self-development, improving the quality of digitalization, revealing scientific and creative potential, developing a value-based attitude towards one's own activities, forming the necessary skills and abilities, and improving education in general. Therefore, the formation of research competence of future specialists involves the manifestation of the ability to self-education, continuous self-development, and the improvement of the quality of digitalization of professional and educational activities, and not only the mastery of scientific research methods. Moreover, such components contribute to increasing a specialist's competitiveness, deepening his skills and knowledge, expanding his scientific worldview, and developing his own professional position on typical problems (Martzoukou et al., 2020).

Let us identify the specific features of the research competence of future specialists that stem from the interdisciplinary nature of their activities. Future specialists must have the ability to implement innovative technologies, critically evaluate innovative technologies and modern methods, digital technologies that are most appropriate to apply in professional activities; be able to combine knowledge from different fields to increase the effectiveness of their professional work; must be able to apply tools and methodological approaches in scientific activities; in particular, be able to use innovative and typical situations, research and problem-solving approaches in solving problems; constantly strive for professional mastery; actively participate in self-development and the process of self-education.

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The creation of a modern educational environment is facilitated by the introduction of digital technologies, which increase the efficiency of the educational process and provide access to self-education and virtual resources. The development of research competence among future specialists is facilitated by tools such as online courses, digital platforms, interactive materials, and applications. Such an educational process contributes to improving the quality of higher education classes. This stimulates the development of critical thinking among future specialists, the systematization and analysis of information, and active involvement in scientific activity, as well as the independent search for necessary materials in educational and professional activities (Chumpitaz Campos & Lomba-Portela, 2024).

The use of digital resources in the development of research competence among future specialists requires students to adhere to academic integrity, which is an important problem in modern scientific life. However, students and young scientists do not always adhere to the principles of academic integrity because they are little aware of the consequences of non-compliance and are also not motivated to engage in open scientific activity. When forming research competence in future specialists, it is worth realizing that an honest scientist, student, future specialist is a person who can identify relevant important scientific research through training and work in a digital environment and direct it to solving modern problems, can identify errors, critically evaluate scientific materials, and, if necessary, cancel outdated data from scientific circulation (Zapata Ancajima, 2022).

Digitalization contributes to the formation of an innovative space in research activities, which ensures students' access to resources, stimulates their educational activities for continuous development, allows them to implement and create an individual digital educational trajectory of future specialists, provides an opportunity to introduce innovative author's developments into the educational process, improve the research system of science and education, in particular. The formation of a digital educational environment during the development of research competence in future specialists is a modern approach to innovative training of a new generation of specialists who, in the context of digital transformations, are focused on modernizing the educational paradigm (Chumpitaz Campos & Lomba-Portela, 2024).

The roles of virtual reality, artificial intelligence, and blockchain technologies in developing students' research competence. The role of the pan-European platform for higher digital education of students.

Digital solutions, blockchain, virtual reality technologies, and artificial intelligence provide practical support in developing students' research competence. In particular, digital tools such as electronic journals, databases, online libraries, and collaboration platforms provide students with access to research materials and a large amount of information, thereby enabling more effective use of data for research, analysis, and search. Artificial intelligence (AI) technologies help automate some aspects of research and data analysis, provide recommendations for ideas and literature, and generate forecasts based on collected data. Virtual reality (VR) technologies enable in-depth study of research objects and complex concepts by simulating real environments. Blockchain technology provides students with data reliability and security in their research, which is helpful for surveys and for preserving the results of experiments used in the study (Moreira et al., 2023).

The student needs to master research competencies in educational and cognitive activities in order to:

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- Navigate through educational and scientific information that is necessary for future professional activity and further educational activity throughout life.
- Develop mental abilities, a clear understanding and representation of the essence of empirical and theoretical approaches to experimentation in students during professional activity, in their own imagination, and in the formation of practical skills and abilities.
- Form critical thinking in students, manage the complex research process, and manage the educational and professional process.
- Master the content of professional disciplines and more actively apply them in the course of professional activity.
- Realize themselves as competent and highly professional specialists in solving various professional problems of reality (Zea et al., 2021).

Today, to expand cooperation between EU Member States, a pan-European platform for higher digital education has been created. With the support of Erasmus+, the new platform is a single resource for blended mobility, online learning, the exchange of best practices across all subjects at higher education institutions (teachers, researchers, students), and virtual campuses (Serrano de Moreno et al., 2024).

To systematically promote digital competence and support scientific research in Europe, continuous training courses in higher education institutions on open science have been introduced for all subjects (researchers, students, teachers). In order to promote media literacy, cyber hygiene, and online security, the EU Member States' educational initiative on cybersecurity, based on the developed system of citizens' digital competence by addressing digitalization issues in education through a pan-European information and educational campaign aimed at parents, teachers, and students, has been supported by society (Moncada et al., 2025).

In order to encourage the development of entrepreneurial and digital competences in students, it is necessary to mobilize all stakeholders to teach digital skills, based on entrepreneurial and digital competences for citizens and to improve the education system by collecting and analyzing forecasting and statistical data through research in educational institutions on digitization and digital technologies, which is an important contribution to the development of digitalization. In this segment, data coordination and more effective collection at the EU level are needed (Zhao et al., 2021).

Research competence reflects personal traits, values, knowledge, and experience of scientific research; it is manifested in the ability to determine the goal, subject, object, task, research hypothesis, research methods, see the programming and essence of the problem, and self-assess the results.

The role of independent work of higher education students in the formation of research competence and participation in academic mobility programs through the use of digital technologies. Independent student work is a cognitive activity that allows students to master practical skills and knowledge in a specific professional field under a teacher's guidance, without the teacher's intervention. Independent work is of great importance in the formation of research competence, because it is this work that orients students to search for new professional scientific information, its generalization, synthesis, analysis, and use in further practical activities. In the course of independent work, it is also appropriate to direct higher education applicants to develop valuable methodological techniques of their own, to test them in the workplace. This approach develops students' research skills, introduces methods of scientific research, and helps solve problems in the field of professional

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activity; it contributes to the deepening of professional knowledge and skills. This approach recognizes the importance of a specialist's research competence as a means of expanding his professional growth, as a tool for communication, and for improving professional skills. In the mobile application of the digital education system, students use resources and services such as Google Classroom, Google Chat, Google Meet, Google Hangouts, Webex, Lucidspark, Zoom, Agile (for planning study of the material), Mentimeter, Canva, Piktochart, and Kahoot. These services enable the student to independently and qualitatively oppose theoretical professional material, where a system of constructive, analytical, and research tasks is of particular importance, the solution and resolution of which contribute to the improvement of students' research skills (González Ramírez et al., 2024).

The formation of research competence in higher education applicants involves their active participation in academic mobility programs. Academic mobility programs are an effective means and an important component in the formation of research competence, aiming to develop a comprehensively developed, innovative researcher with an international academic orientation. Involving future specialists in such programs allows: to gain experience in intercultural scientific communication; to know the research methodology of leading foreign scientific and educational institutions; to develop critical and analytical thinking, a scientific worldview; to compare different approaches to organizing research activities; to establish professional ties with the international scientific community, which is important for joint future projects, publications, grants; improve your level of proficiency in a foreign language (Lagunes et al., 2016).

Experimental research

In the course of our research, a technology for the development of research competence in future specialists through the use of digital technologies, which is necessary for modern professional human activity, has been developed and substantiated.

The features of the formation of research competence in future specialists through the use of digital technologies have been highlighted, including pedagogical conditions, a special course, methods, forms, and principles (significance, pedagogical expediency, methodological effectiveness of the use of digital technologies, educational value). It has been proven that introducing innovative technology should be implemented in higher education.

The following components of the formation of research competence have been identified: motivational, cognitive, and technological.

The following criteria have been outlined, reflecting the specifics of the formation of research competence: motivational, gnostic, and activity, along with their indicators and levels of formation (low, average, high).

The motivational criterion is characterized by development and a stable focus on improving professional results and the personal qualities of a specialist. The key aspect of the use of digital technologies in the concept of motivation for the formation of research competence in future specialists is the possibility of a personal development path, with higher education applicants freely choosing their development trajectory, which is directly related to society and professional activity through research.

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Indicators of the motivational criterion include motives and cognitive interest in professional activity based on digital technologies; a perceived need to master research activities, digital technologies in self-education, self-improvement, and awareness of the role of digital technologies for a modern specialist, and their impact on the formation of research competence.

The gnostic criterion characterizes the knowledge acquired for the formation of research competence through the use of digital technologies that improve the educational process. This criterion, in the context of society's digitalization, includes the acquisition of professional knowledge.

The gnostic criterion correlates with the indicators: knowledge of search information systems, knowledge of various digital information sources, and knowledge of methods and forms of research with digital technologies to develop research competence.

The activity criterion includes the presence of professional skills and abilities necessary for specialists to use and implement digital technologies in their professional activities effectively.

The indicators of this criterion include: the use of digital technologies for the formation of research competence, the implementation of information and methodological support for the activities of future specialists; the use of digital technologies during the teaching of new material and for organizing control and verification of knowledge, for organizing joint work, organizing group work, visualizing educational material, for ensuring the research competence of students using various resources; drawing up individual learning trajectories.

Next, we assessed the state of students' research competence development. For this, an ascertaining stage of the experiment was conducted, the purpose of which was to assess the current level of the development of research competence through the use of digital technologies, according to the selected criteria, their indicators, and the named levels.

Table 1.
Levels of research competence formation among future specialists at the ascertaining stage (using digital technologies)

Components	Development levels %		
	Low	Average	High
Motivational	38,2	52,1	9,7
Cognitive	50,1	41,5	8,4
Technological	30,6	61,1	8,3

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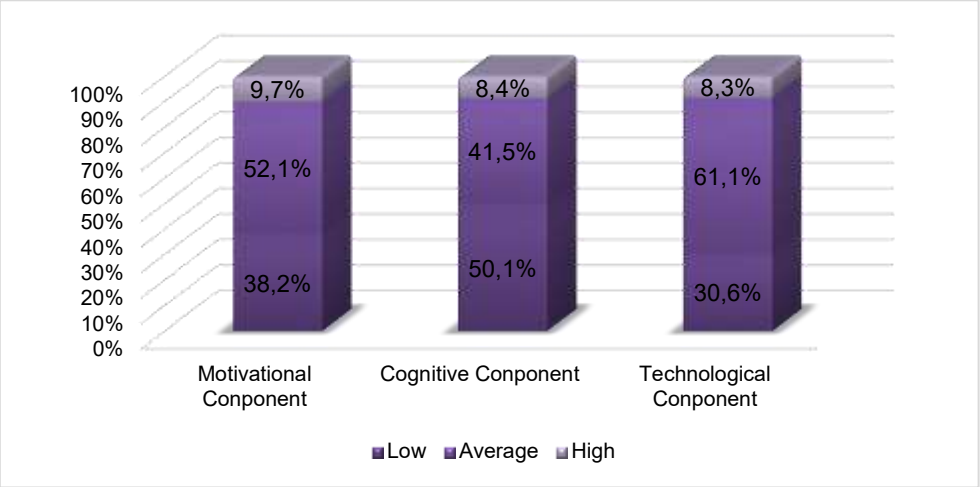


Fig. 1. Levels of research competence formation among future specialists at the ascertaining stage (using digital technologies)

As we can see, most students have an average and low level of research competence in their future professional activities.

We formulated the following statistical hypotheses for the mathematical processing of the data obtained during the study, which were tested according to each criterion:
Null hypothesis (H0): the differences between the two distributions are not significant;
Alternative hypothesis (H1): the two distributions differ significantly.

We used the Kolmogorov-Smirnov λ-criterion to test the formulated hypotheses, allowing us to determine whether they are consistent and to compare the two empirical distributions. Calculations were performed using Microsoft Excel spreadsheets. The analysis of the calculation results at the 0.05 level indicates that the distributions of the students' scores are not statistically different.

Comparison, according to the results of the ascertaining experiment, of these empirical values for the significance levels with the critical values of the λ-criterion $p \leq 0.05$ and $p \leq 0.01$.

$$\lambda_c = \begin{cases} 1{,}36, & p \leq 0{,}05 \\ 1{,}63, & p \leq 0{,}01 \end{cases}$$

shows that the following relationship holds for all components of students' digital competence formation: $\lambda_e < \lambda_c$

It is proven that there are no statistically significant differences between the respondents of the CG and EG in terms of the levels of formation of indicators and components of digital competence. That is, according to this studied characteristic, the groups (EG and CG) are similar to each other.

At the beginning of the experiment, the empirical value of Kolmogorov-Smirnov λ does not exceed the critical 1.36 for all criteria. Comparing the distributions of students, we found differences at the 0.05 level for all criteria (exceeding the critical value of 1.36 for the empirical Kolmogorov-Smirnov statistic λ). Calculations were performed using Microsoft Excel spreadsheets.

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Based on the conducted research, we have identified the problem area of the formation of research competence in professional training through the use of digital technologies: the need to modernize the higher education system in connection with the expansion of the areas of use of digital technologies, digitalization processes in modern society, increasing the qualitative characteristics of the development of methodological computer-oriented training systems; insufficient formation of research competence through the use of digital technologies; introduction and implementation of reforms of the digitalization of higher education.

Thus, the conclusions obtained regarding the conducted ascertaining stage of the experiment (132 respondents were interviewed), which aimed to assess the current level of formation of research competence of students through the use of digital technologies in educational and professional activities, showed that the majority of students have a low and average level of formation of research competence.

Introduction of pedagogical technology for the formation of research competence in future specialists through the use of digital technologies, developed pedagogical conditions, and an author's special course

The presented results of the ascertaining stage of the experiment made it possible to develop and substantiate the need for a pedagogical technology for the formation of research competence in future specialists through the use of digital technologies, developed pedagogical conditions, and an author's special course in the educational and professional activities of specialists, and to select the appropriate tools for this purpose.

In the study of all subjects trained in higher education in the EG, we will focus on creating conditions for positive motivation to use digital technologies.

When developing the author's technology, the following approaches were used (competence, synergy, system, personality, axiological, situational) and principles (general: scientificity, strength of knowledge, adaptability, accessibility, manageability, individualization; specific: expediency of using digital technologies, use of software, visualization, clarity, gamification, identification, activity, interactivity of learning).

The choice of methods and forms used in the author's technology developed by us was based on their universality and interactivity, to involve all participants in the EG of the experimental study in the educational process. It was believed that such an approach would enable a high level of activity in the subjects' EGs. In particular, the following forms of the educational process were used: multimedia lecture, lecture-visualization, lecture-press conference, lecture-debate, binary lecture, master classes, trainings, seminar classes, round tables, virtual consultations, webinars, blended learning, and video conferences. The following teaching methods were effective: mobile learning interaction, brainstorming, interactive portfolio, problem-based case method, flipped learning, scribing, game design, and web-quest.

The following digital resources were selected for the implementation of EG technology: tools for working in real time: Genially, Sway, Zeetings, Canva, Classtime, Pear Deck, Classkick; tools for visualization: Genially, Padlet, H5p, Learningapps, Thinglink, Smore, Bitmoji; tools for organizing research work: Notion, Google Calendar, Wakelet, Exel, Google Chrome, Word; Internet services for using group research: Google Slides Presentation, Padlet; assessment programs: Liveworksheets, Wizer, Core, Classtime, Quizizz, Learningapps, Wordwall,

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Classtime, Kahoot, Triventy, Edpuzzle, Quillionz, Mentimeter; tools for implementing 3D technologies in research: Google Arts & Culture, Emaze, Learnis, Prezi; Internet services for creating interactive tasks: LearningApps, Genially, Quizlet, H5P, Wordwall, Playfactile, Baamboozle, Quizlet.

Analysis and interpretation of research results

We will present and analyze the results of experimental work on the implementation of pedagogical technology for the formation of research competence in future specialists through the use of digital technologies, developed pedagogical conditions, and an author's special course offered to EG during the students' studies at the university. The experimental work consisted of sequential, interrelated stages aimed at achieving the goal set at the beginning of the study.

At the first search stage, the study's goal was set, and the main directions of the analysis of the scientific literature were selected, which allowed us to investigate the conditions for the formation of research competence (principles, forms, and methods) and identify the main components: motivational, cognitive, and technological.

The experimental stage contributed to the development of criteria for the formation of research competence: motivational, gnostic, and activity. The levels and indicators of the problem under study (high, average, low) were described.

The declarative stage of the experiment involved an assessment of the existing level of research competence development.

The beginning of the creative stage was the development of a pedagogical technology for the formation of research competence in future specialists through the use of digital technologies, the establishment of pedagogical conditions, and an author's special course, during which approaches, criteria, and principles were identified.

The formative stage of the experiment, conducted after the development of pedagogical technology, conditions, and a special course, provided for their practical implementation in students' educational process to verify and confirm the research's effectiveness. 184 respondents with the same level of research competence, developed through the use of digital technologies, participated in the experiment. They were divided into two groups: control (CG) and experimental (EG).

The content of the pedagogical technology includes the developed pedagogical conditions:

- Improvement taking into account the trends of digitalization of educational components.
- Organization of students' research activities using web technologies.
- Formation of the dynamic content of training future specialists in order to form research competence through the use of digital technologies.

We monitored the level of development of research competence through the use of digital technologies in educational and professional activities in the experimental and control groups, using all criteria. The final element was the statistical processing of the results.

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We formulated the following statistical hypotheses to conduct a mathematical analysis of the research data we received.

Null (H0) hypothesis - the level of readiness for the formation of research competence through the use of digital technologies of the control group did not significantly differ from the level of readiness of students in the experimental group according to each assessment criterion, and the corresponding differences between the groups are due to random factors.

Alternative (H1) hypothesis: There are significant differences in readiness levels between the experimental and control groups for each assessment criterion.

We used the Kolmogorov-Smirnov λ-statistic to test the formulated hypotheses. Results of comparison of distributions of control and experimental groups of students, future teachers of humanities, by levels of readiness to use digital technologies in professional activities at the ascertaining and formative stages of the experiment. Calculations were performed in Microsoft Excel.

Analysis of the results of calculations at the 0.05 level between the experimental group and the control group for all criteria at the beginning of the experiment indicates a statistically insignificant difference. The empirical value of Kolmogorov-Smirnov λ does not exceed the critical 1.36.

When comparing the control group before and after the experiment, no statistically significant differences were identified, as the empirical value of the Kolmogorov–Smirnov test did not exceed the critical value (λ_{crit} = 1.36).

In contrast, the comparison of the experimental group based on the results of the experiment revealed statistically significant differences. The empirical values of the Kolmogorov–Smirnov test (λ = 2.539; 2.878; 4.120; 3.136; 2.935) exceeded the critical value, confirming the effectiveness of the implemented pedagogical conditions.

Note that when comparing the distributions of the control and experimental groups before the experiment, we test the null hypothesis H0; after the experiment, we test the alternative hypothesis H1. Therefore, we conclude that at the beginning of the experiment, respondents in both groups had the same statistically indistinguishable level of formation of research competence through the use of digital technologies; however, at the end of the experiment in the EG, statistically significant dynamics are observed in the levels of formation of research competence for each of the components. No significant changes occurred in the control group.

Thus, we can say that the changes that occurred in the experimental groups are not accidental; the increase in the level of formation of research competence through the use of digital technologies in educational and professional activities is the result of the innovative pedagogical technology developed and introduced into the EG, the developed pedagogical conditions, and the author's special course.

Using the methodology described above, we will analyze the obtained EG results separately for each component.

Let us consider the level of formation of research competence of future specialists through the use of digital technologies for all components (formative stage).

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The results showed that the number of respondents at the average and high levels increased, thereby reducing the percentage of respondents at the low level.

Table 2.
Levels of research competence formation among future specialists at the formative stage (using digital technologies)

Components	Development levels %		
	Low	Average	High
Motivational	5,8	52,1	42,1
Cognitive	8,4	53,5	38,1
Technological	8,3	63,2	28,3

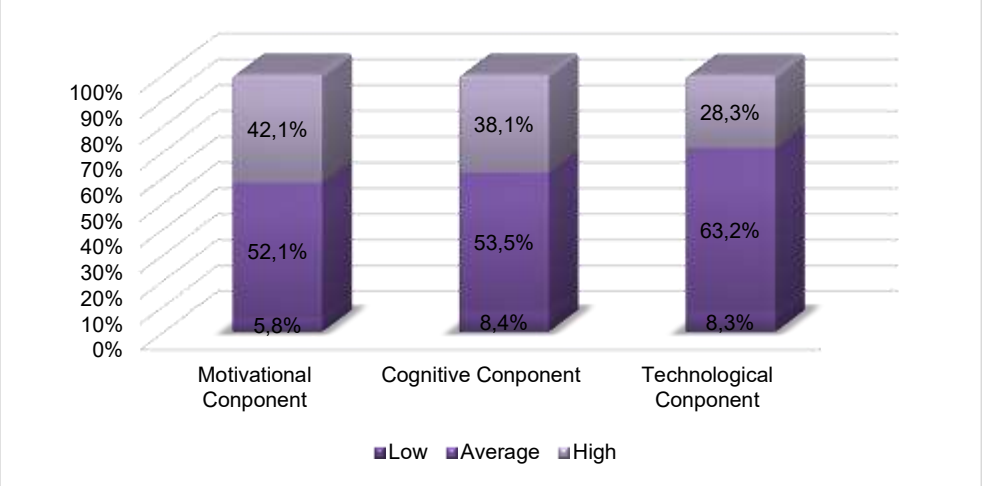


Fig. 2. Levels of research competence formation among future specialists at the formative stage (using digital technologies)

During the formative experiment, the experimental group showed significant increases in digital competence, whereas the control group showed practically no change.

As before, after the formative experiment, an assessment was made using the Kolmogorov-Smirnov λ-criterion of the distributions of applicants in the EG and CG (regarding the formation of digital competence) and of the statistical reliability of changes at all levels of formation of components and indicators. Based on the data, empirical values of the criteria were calculated from these distributions. It allowed us to conclude by comparing these values for significance levels with critical values of the criterion ≤ 0.05 and $p \leq 0.01$:

$$\lambda_c = \begin{cases} 1{,}36, & p \leq 0{,}05 \\ 1{,}63, & p \leq 0{,}01 \end{cases}$$

Regarding their statistical validity, in particular, the changes identified.

Thus, the analysis of the experimental results showed that in the EG, most respondents have a high and average level of formation of research competence through the use of digital technologies (formative stage based on the results of the experiment). In comparing the experimental and control groups, we observed significant differences according to all criteria for the formation of research

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competence at the 0.01 level (the empirical value of λ for the Kolmogorov-Smirnov test exceeds the critical value of 1.63). Regarding the comparison of the experimental group results, we observe significant differences (the empirical value of λ for the Kolmogorov-Smirnov test exceeds the critical value of 1.63). Therefore, the changes observed in the experimental groups are not accidental; the increase in the level of formation of research competence among students in these groups is the result of the pedagogical technology we proposed, the developed pedagogical conditions, and the author's special course.

The findings of this study provide empirical support for the effectiveness of an integrated pedagogical technology in developing research competence through digital technologies. While prior research has consistently emphasized the importance of digital tools and active learning strategies in fostering research-related skills, the present results extend this body of knowledge by demonstrating the added value of a holistic, multi-component pedagogical model.

Critical Comparison with Previous Studies

The significant improvements observed in the experimental group are consistent with previous intervention-based studies that highlight the role of problem-based and technology-supported learning in enhancing research competence (Paucar-Curasma et al., 2025; Winchez Aylas & Bejarano Alvarez, 2025). However, unlike these studies, which typically focus on isolated instructional strategies (e.g., problem-solving methods, flipped learning, or workshops), the present study implemented a comprehensive pedagogical technology integrating motivational, cognitive, and technological components. This integrated approach may explain the stronger and more systematic improvements observed across all components of research competence.

Furthermore, the results partially converge with Beaulieu et al. (2024), who emphasize reflective and boundary-spanning competencies in collaborative research contexts. While their framework is primarily organizational and practice-oriented, the present study demonstrates how such competencies can be pedagogically scaffolded within higher education through structured instructional design and targeted digital tools. In this respect, the current findings bridge a gap between conceptual models of research competence and their operationalization in formal educational settings.

The dominance of summative assessment practices identified by Espinoza-Montes et al. (2025) contrasts with the approach adopted in the present study, which embedded continuous monitoring and formative feedback within the pedagogical technology. The observed post-test gains suggest that aligning instructional strategies with formative-oriented assessment may be a critical factor in achieving sustainable development of research competence.

Interpretation of the Findings

The statistically significant gains in the experimental group across motivational, cognitive, and technological components indicate that research competence development is not solely a function of exposure to digital tools. Rather, the findings suggest that structured pedagogical conditions and purposeful instructional design mediate the impact of digital technologies. This supports theoretical perspectives that conceptualize competence as an integrative construct, combining knowledge, skills, values, and motivation, rather than as a purely technical capacity.

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Importantly, the strongest gains were observed in components directly linked to active engagement and self-directed learning, suggesting that the pedagogical technology facilitated not only skill acquisition but also the internalization of research-oriented attitudes and practices. This finding aligns with constructivist and competence-based learning theories, which posit that sustained competence development requires meaningful learner participation and reflective engagement.

Original Contribution of the Study

The original contribution of this study lies in the development and empirical validation of a holistic pedagogical technology that systematically integrates digital tools, pedagogical conditions, and an author's special course into a coherent instructional model. Unlike many previous studies that examine individual digital tools or isolated pedagogical techniques, this research offers a scalable and theoretically grounded framework for the formation of research competence in higher education.

Additionally, the study contributes methodologically by operationalizing research competence through a three-component structure (motivational, cognitive, technological) and by empirically testing changes using a quasi-experimental design. This provides a more nuanced understanding of how different dimensions of research competence respond to pedagogical intervention.

Methodological and Contextual Limitations

Despite these contributions, several limitations must be acknowledged. First, the quasi-experimental design, while appropriate for educational settings, limits the ability to draw strong causal inferences compared to fully randomized controlled trials. Second, the sample was drawn from a specific institutional and national context, which may restrict the generalizability of the findings to other educational systems or cultural environments.

Third, the measurement instruments relied in part on self-reported data and expert evaluations, which may be subject to response bias and subjectivity. Future studies should incorporate additional objective performance-based measures and longitudinal designs to examine the sustainability of the observed effects over time. Finally, the intervention was implemented within a relatively defined academic period. Longer-term implementation and replication across disciplines would be necessary to assess the robustness and transferability of the proposed pedagogical technology.

Conclusions

This study examined the formation of research competence in future specialists through the use of digital technologies and provides empirical evidence for the effectiveness of an integrated pedagogical technology. The findings demonstrate that the systematic alignment of pedagogical conditions, instructional methods, and digital tools leads to statistically significant improvements in students' motivational, cognitive, and technological components of research competence. These results suggest that research competence development is not achieved through the mere introduction of digital technologies, but rather through their pedagogically structured and theoretically grounded integration into the educational process.

The study makes an original contribution by developing and empirically validating a holistic pedagogical technology that integrates digital resources, an author's special

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course, and clearly defined pedagogical conditions within a coherent instructional framework. Unlike previous studies that have primarily focused on isolated tools or individual teaching methods, this research offers a comprehensive model that operationalizes research competence as a multidimensional construct and demonstrates how its components can be systematically developed in higher education. This integrated approach represents a novel contribution to the literature on research competence and digital pedagogy.

At the same time, the results should be interpreted in light of several methodological and contextual limitations. The quasi-experimental design limits the strength of causal inferences, and the sample was drawn from a specific institutional and national context, which may restrict the transferability of the findings to other higher education systems. In addition, the reliance on a combination of self-reported measures and expert assessments may introduce subjective bias. The relatively limited duration of the intervention also constrains conclusions regarding the long-term sustainability of the observed effects.

Despite these limitations, the findings have important theoretical and practical implications. The results support competence-based and constructivist perspectives by demonstrating that integrated pedagogical design enhances not only technical skills but also motivational and cognitive dimensions of research competence. For practice, the study underscores the need for higher education institutions to move beyond fragmented uses of digital tools and to adopt comprehensive pedagogical technologies aligned with clearly articulated competence outcomes.

Future research should focus on replicating the proposed pedagogical technology in diverse institutional, disciplinary, and cultural contexts, as well as on conducting longitudinal studies to assess the durability of its effects. Such research would further clarify the generalizability and scalability of the model and contribute to the development of evidence-based strategies for fostering research competence in digitally transformed higher education environments.

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Original Article

Academic confidence and language anxiety as predictors of readiness for international exchanges

Confianza académica y ansiedad lingüística como predictores de la preparación para intercambios internacionales

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Abstract

This study analyzes the linguistic readiness of higher education students to participate in international academic exchanges and identifies barriers to successful language acquisition. Utilizing a quantitative correlational-descriptive design, the research surveyed 220 Ukrainian university students involved in academic mobility programs. Readiness was assessed through a proficiency test and self-assessment scales. Data analysis included descriptive statistics, Pearson correlation, and multiple linear regression. Results indicate that while most students possess average readiness, they excel in reading but struggle with academic writing and speaking. Three barrier groups emerged: linguistic, psycho-emotional, and organizational. Regression analysis revealed that academic confidence (β = .45), language anxiety (β = –.29), and self-assessment (β = .24) are key predictors, with the model explaining 40% of the variance in linguistic readiness. The study highlights the critical role of psychological factors and individual learning strategies over institutional support. Recommendations include integrating systematic English for Academic Purposes (EAP) courses and anxiety-reduction strategies to better prepare prospective exchange students.

Keywords: academic mobility, English for Academic Purposes (EAP), academic confidence, higher education internationalization, language anxiety.

Resumen

Este estudio analiza la preparación lingüística de estudiantes de educación superior para participar en intercambios académicos internacionales e identifica barreras para la adquisición exitosa del idioma. Utilizando un diseño descriptivo-correlativo cuantitativo, la investigación encuestó a 220 estudiantes universitarios ucranianos involucrados en programas de movilidad académica. La preparación se evaluó mediante una prueba de competencia y escalas de autoevaluación. El análisis de datos incluyó estadística descriptiva, correlación de Pearson y regresión lineal múltiple. Los resultados indican que, si bien la mayoría de los estudiantes poseen una preparación promedio, sobresalen en lectura, pero tienen dificultades con la escritura y el habla académicas. Surgieron tres grupos de barreras: lingüísticas, psicoemocionales y organizacionales. El análisis de regresión reveló que la confianza académica (β = .45), la ansiedad lingüística (β = –.29) y la autoevaluación (β = .24) son predictores clave, y el modelo explica el 40% de la varianza en la preparación lingüística. El estudio destaca el papel crítico de los factores psicológicos y las estrategias de aprendizaje individuales sobre el apoyo institucional. Las recomendaciones incluyen la integración de cursos sistemáticos de Inglés para Fines Académicos (EAP) y estrategias de reducción de la ansiedad para preparar mejor a los futuros estudiantes de intercambio.

Palabras clave: movilidad académica, inglés académico (EAP), confianza académica, internacionalización de la educación superior, ansiedad lingüística.

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Introduction

The participation of higher education students in international academic exchanges is an important mechanism for the internationalization of universities and increasing their competitiveness in the global educational space. In particular, the Erasmus+, DAAD, Fulbright programs, and other initiatives have created holistic conditions for the development of an academic mobility environment, the formation of intercultural competence, integration into international scientific communities, and the development of skills that are in demand in the modern labor market. For this reason, the linguistic readiness of students plays the role of an important role in successful participation in mobility. In particular, the quality of language training determines academic success during a semester abroad, the effectiveness of intercultural communication, and the ability to integrate into the institutional environment of the host university (Du & Lei, 2023). Previous studies have indicated that insufficient proficiency in a foreign language is one of the main barriers to academic mobility. In addition, researchers have drawn attention to the existence of a gap between the formal level of language proficiency (B1/B2 certificates) and the real communication skills necessary for academic writing, participation in discussions, working with scientific texts, and completing project tasks (Conceição, 2020; Witkowsky, 2024). Research in the field of applied linguistics has additionally pointed to the importance of academic English (EAP), culturally colored speech practices, critical reading skills, and strategies for overcoming language anxiety. In the countries of Central and Eastern Europe, another dimension is added - inequality in access to quality language training. Thus, the problem of students' linguistic readiness for academic mobility has not only a global but also a clearly expressed regional dimension. In many Central and Eastern European countries, structural limitations of the higher education system – in particular, unequal access to language resources, different levels of institutional support, and limited presence of native speakers – exacerbate the challenges that are recorded in international research. In this context, Ukraine is not an exception but rather represents an extreme case of the accumulation of global and regional factors that affect students' linguistic preparation for participation in international academic exchanges (Jones & Murray, 2025).

This is due to the different material and technical bases of universities and the presence of native speakers. In addition, for Ukraine, the issue of linguistic readiness is gaining relevance due to the intensification of universities' participation in European mobility programs and the growing need for students to implement individual educational trajectories outside the country. In the conditions of martial law and the digital transformation of education, new challenges have arisen. Researchers have pointed to the reduction of classroom hours in a foreign language, unequal access to resources, decreased motivation, and increased language anxiety (Gacel-Ávila, 2021). These challenges have highlighted the importance of developing students' linguistic competence, which is valuable not only for communication but also for broader academic, professional, and intercultural integration. This makes this study particularly relevant.

Accordingly, the purpose of this study is a comprehensive analysis of the linguistic readiness of higher education students to participate in international academic exchanges.

The objectives of the study are as follows:

1. To determine the level of linguistic readiness of students of Ukrainian universities based on empirical data (testing, questionnaires, self-assessment).

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2. To identify the main difficulties and barriers that arise during language training and participation in exchanges.
3. To identify strategies that students and universities use to increase language and academic readiness
4. To formulate practical recommendations for universities on optimizing the language training of participants in international programs.

Literature Review

Internationalization processes in modern higher education institutions have become key transformations. Student and faculty mobility, transformations of educational content, language regimes, and academic practices have become an objective reality, including for Latin American countries. In particular, some studies have shown that the region has gradually increased its participation in international mobility (Barbosa & Neves, 2020). However, the share in the global dimension is quite small, and many cases were intraregional in nature. Researchers, having analyzed international trends and analytical information from Latin America and the Caribbean, have shown the unevenness of internationalization (Diniz de Figueiredo et al., 2021; Mattos & Diniz, 2025). Leading national universities are actively developing partnerships, using practices such as granting double degrees, exchange programs, etc. On the other hand, smaller universities have retained a primarily local orientation. In such conditions, language policies, in particular the dominance of Spanish and Portuguese, and the limited presence of English, have become a structural factor of internationalization. Other recent studies have shown, using the examples of Brazil and Peru, that official university internationalization strategies are primarily available to students with higher socio-economic status (Turchyn et al., 2023; Guimarães et al., 2020). Similar results can also be projected to other countries of the global South, and also to Eastern European realities. In particular, institutional constraints, financial difficulties and language requirements (the need to prove the level of English or another language of instruction) have constituted significant obstacles to the expansion of academic mobility in this region.

Researchers have also emphasized the paradigm of thinking of education seekers, since foreign language proficiency is not only a consequence of studying abroad (Yu et al., 2024; Maringe, 2022). It was noted that it was a determinant of the decision to go on exchange, that is, students chose those destinations where the language requirements seemed achievable to them. On the other hand, it was also noted that participation in study abroad programs contributed to significant increases in language competence (especially in the field of speaking) (Lima-Lopes & Biazi, 2021; Martin-Jones et al., 2024). In the Latin American context, there is little empirical data on academic exchanges. First of all, the focus is on the problem of the linguistic dimension of internationalization and on the fact that the insufficient level of English proficiency among teachers and students was a systemic limitation (Tavares, 2021; Atobatele et al., 2024). Generalizing research publications have shown that most scientific works in this field were focused on the social sciences and humanities, and there was a noticeable shortage of studies that would systematically assess the language readiness of students from non-English-speaking countries (Tejada-Sanchez & Molina-Naar, 2021; Guimarães & Hildeblando Júnior, 2021; Ivashchuk et al., 2023).

Some studies have suggested the introduction of English as the language of instruction. In particular, Colombia has moved from pilot courses to a broader implementation, accompanied by internal language courses, teacher training, and adaptation of teaching materials (Barger & Sandoval Rubilar, 2020; Gimenez & Morgan, 2014). Similar results have been obtained by other scholars,

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including Reus, who has demonstrated the effectiveness of introducing finance and industrial organization courses in English as a way to reduce the region's "linguistic isolation" (Reus, 2020). With better language preparation, students would become more relevant to the global labor market. Research outside the Latin American region has confirmed the central role of language readiness in academic mobility. Review studies have shown that study abroad programs in Europe and beyond lead to significant gains in language competence (Lysiuchenko, 2021; Kamaşak et al., 2021). However, the best effect was recorded for those students who already had a certain minimum threshold of language proficiency (as a rule, a level not lower than B1–B2) (Escobar-Alméciga, 2022). Research by other scientists made it possible to determine that the level of proficiency in the target language (or English as the language of instruction) significantly influenced the decision to go to another country to study (Ennser-Kananen & Saarinen, 2023).

Alongside studies on Latin American and Global South countries, the European context of academic mobility has gained increasing attention in the academic literature, particularly within the European Higher Education Area (EHEA). Studies conducted in Central and Eastern European countries have shown that for students from non-English speaking education systems, language readiness is also a key factor in participating in mobility programmes, particularly within Erasmus+ and related initiatives. In particular, the authors have noted a gap between formally certified language proficiency and the real academic and communicative competences required for studying abroad, participating in seminars, preparing written papers and intercultural interaction.

Empirical studies in Poland, the Czech Republic, the Baltic States and the Balkans have shown that students from regions with limited language resources are more likely to experience language anxiety, academic insecurity and difficulties in integrating into the educational environment of host universities. Together with financial and institutional constraints, this has created systemic barriers to full participation in European mobility programmes. In this sense, the Ukrainian context is close to the broader Eastern European reality, where students' language readiness has determined not only access to mobility but also the quality of their educational experience abroad.

Thus, several important aspects have been demonstrated in the modern scientific literature. First of all, language readiness is recognized as a critical factor in access to mobility programs, selection of the necessary country, potential academic success and psychological well-being of students. Secondly, for the realities of Latin America, the language factor is often considered at the macro level - empirical studies of individual linguistic readiness of students are only isolated. The same situation is also inherent in the realities of other regions, in particular Ukraine and Central Europe in general. Accordingly, it is necessary to combine quantitative and qualitative approaches to analyze students' sense of language readiness. Closing the empirical gap under such conditions is an extremely important task.

Methodology

The study had a quantitative, empirical, descriptive-correlation design. The study was conducted in a cross-sectional study format and using standardized language testing and a questionnaire. This design made it possible to combine the analysis of objective indicators of language preparation (test results) with students' subjective perceptions of their own readiness to participate in international programs.

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Participants and sample

The study involved 220 higher education applicants from four Ukrainian universities that have valid academic mobility agreements (including Erasmus+ programs and bilateral agreements). The sample included students:

2–4 years of bachelor's degree and 1 year of master's degree;
humanities, socio-economic and technical specialties;
who studied English as a foreign language and had a level of proficiency not lower than B1 according to CEFR (according to university exams or certificates).

Inclusion criteria included the following aspects:

1. Full-time higher education student status;
2. English as the main foreign language;
3. Previous experience in academic mobility competitions;
4. Declared intention to participate in such programs within the next two years;
5. Voluntary informed consent to participate in the study.

Exclusion criteria:

1. Study in a fully English-language program (EMI) lasting more than two years (to avoid a significant bias in favor of a very high level of language proficiency);
2. Refusal to participate at any stage of the study;
3. Incomplete completion of key blocks of the questionnaire.

Among the 220 participants, approximately 65–70% were women and 30–35% were men, and their ages ranged from 18 to 25 years. Some of the students (about a third of the sample) had previous experience of short-term study trips, summer schools or language courses abroad, which allowed comparing groups with different levels of international experience. The sample is purposive sampling, since it involved only those higher education students who are potential participants or candidates for participation in international academic exchanges.

Table 1.
Characteristics of Participants (N = 220)

Indicator	Category	n	%
Gender	Women	148	67.3%
	Men	72	32.7%
Age	18–19 years	64	29.1%
	20–21 years	98	44.5%
	22–25 years	58	26.4%
Educational level	Bachelor's degree (2–4 years)	178	80.9%
	Master's degree (1 year)	42	19.1%
Specialties	Humanities	84	38.2%
	Socio-economic sciences	56	25.5%
	Technical specialties	80	36.3%
Certified level of English	B1	92	41.8%
	B2	104	47.3%
	C1	24	10.9%
Previous international experience	No	152	69.1%
	Yes (short trips, schools, courses)	68	30.9%
Intention to participate in international exchanges during the year	Yes	164	74.5%
	No / Unspecified	56	25.5%

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Instruments and Procedure

A variety of tools were used to collect data, which are aimed at assessing linguistic readiness in several dimensions.

1. Linguistic readiness test for academic mobility

A written test developed based on CEFR descriptors and academic English requirements (EAP). The test included four blocks:

Academic reading (reading) – work with an authentic fragment of a scientific/educational text in English with tasks on 1. understanding the main content; 2. Interpreting the argument; 3. working with terms and references.

Academic writing (writing) – a short-written task (150–200 words), where students had to formulate a position on participation in academic mobility and use the basic elements of academic style (linking words, hedging, references).

The lexical and grammatical block consists of tasks on the use of academic vocabulary, recognition of formal and informal constructions, and typical grammatical structures of academic discourse.

Mini-case “academic situation” – a description of a simulated situation (seminar, group project, correspondence with the program coordinator), where it is necessary to choose adequate language formulas and demonstrate understanding of communicative norms.

The overall score reflected the integral index of linguistic readiness, which was then used as a quantitative indicator for further analysis.

2. Questionnaire “Linguistic readiness for international academic exchanges”

The questionnaire consisted of several blocks, designed on a 5-point Likert scale (1 – “completely disagree”, 5 – “completely agree”):

Self-assessment of language competence (competence in reading, writing, speaking, listening in an academic context).

Academic self-efficacy – a sense of ability to:
write essays, reports, abstracts in English;
prepare presentations;
participate in discussions.

Language anxiety – emotional reactions associated with the need to communicate in English in a foreign-language academic environment (based on adapted statements from the FLA scales).

Coping strategies – use of resources:

language courses, conversation clubs, online platforms;
tandem learning, teacher consultations;
digital and AI tools to support speaking and writing.

Intercultural readiness – openness to another academic culture, readiness to

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interact with foreign students and teachers, tolerance for uncertainty.

The questionnaire also included a socio-demographic block: age, course, specialty, level of certified English, experience of living abroad, participation in international programs.

3. Semi-structured open-ended questions (optional)

At the end of the questionnaire, 2–3 open-ended questions were offered, where participants could:

describe their main fears and expectations regarding studying abroad;
name what kind of language support they considered most necessary.

The answers received were used to supplement the quantitative results qualitatively.

Participants were recruited from academic mailing lists. Information messages from international relations departments and announcements in electronic learning environments (LMS, Google Classroom, etc.) were also used.

The linguistic readiness test developed by the authors previously underwent a validation process. For this purpose, a pilot study was conducted on a separate group of students (n ≈ 30–40) who met the same inclusion criteria as the main sample. The pilot study made it possible to check the clarity of the instructions, the adequacy of the task completion time, and the internal consistency of the test components.

The content validity of the instrument was ensured by expert assessments. The test structure and task formats were analyzed by three experts in applied linguistics and English for Academic Purposes (EAP), who assessed the correspondence of the test tasks to typical academic communicative situations encountered by education seekers during participation in international academic mobility programs. Based on the results of the expert analysis, minor adjustments were made to the wording of individual tasks.

The reliability of the test was assessed using the Cronbach's alpha coefficient of internal consistency. The overall reliability of the test demonstrated an acceptable level ($\alpha \geq 0.78$).

Participation format

The language test was conducted in a classroom or online format (with time control, 40–50 minutes).

The questionnaire was filled out online (Google Forms or another platform) and took about 15–20 minutes.

The data were collected without specifying personal data. To ensure anonymity, each participant was assigned a code.

The results were used only in a generalized form.

In addition, students could discontinue participation at any point without giving a reason. Participation did not affect their academic performance.

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Data analysis

Data processing was carried out using statistical software (SPSS / R).

At the preparatory stage, data were checked for completeness and variable coding and reversal of the corresponding items were carried out.

Descriptive statistics consisted of calculating mean values, standard deviations, minimum/maximum values for indicators of linguistic readiness, self-esteem, anxiety, strategies; distribution of participants by language test level and previous international experience. Correlation analysis was conducted to establish the relationship between the results of the language test and self-esteem of language readiness, academic confidence, level of language anxiety and use of strategies.

Comparative analysis of groups was carried out based on the comparison of participants with/without previous international experience. Groups with different levels of English proficiency (levels B1, B2, C1) were also compared for indicators of anxiety, academic confidence and strategies. The study carried out modeling of predictors of linguistic readiness and compiled a multivariate regression model, in which the dependent variable was the integral indicator of linguistic readiness (a combination of test results and self-assessment), and the independent variables were: level of language proficiency; academic confidence; language anxiety; intensity of strategy use; previous international experience.

Results and Discussion

The average integral score of the language test for Ukrainian university students was 62.4 points out of 100 (SD = 12.7). This generally indicated an average level of readiness. Three groups were distinguished according to the assessment scale:

High level of readiness (≥75 points) – 18.6% of students
Average level (55–74 points) – 56.8% of students
Low level (<55 points) – 24.6% of students

The participants showed the best results in academic reading tasks (M = 68.2), the lowest – in academic writing tasks and formulating reasoned answers (M = 57.1). Case tasks related to communication in academic situations (correspondence with the coordinator, formulating a request, participating in a discussion), where the average score was 59.4, were of particular difficulty (See Figure 1).

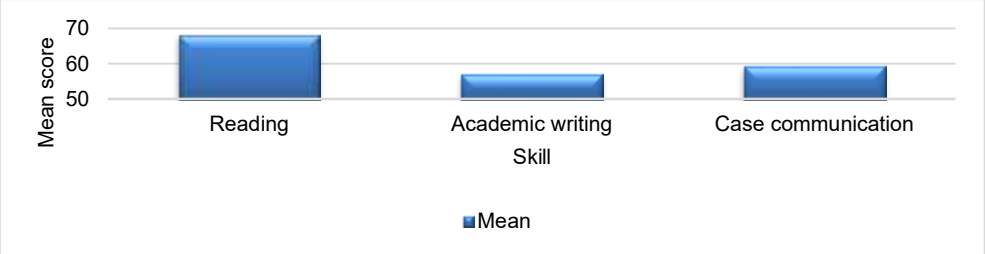


Figure 1. Average Scores by Linguistic Skill.

The questionnaire data showed that students rated their language competence somewhat higher than the test results showed. The average self-assessment of language readiness was 3.62 on a 5-point scale (SD = 0.71).

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The highest self-assessments were for the following activities:

understanding academic texts (M = 3.87),
working with educational materials in English (M = 3.74).

The lowest self-assessments were for the following: participating in oral discussions (M = 3.21), academic writing (M = 3.18), and presentations in English (M = 3.09).

A comparison of groups showed that students with prior international experience demonstrated significantly higher self-assessment (M = 3.95) compared to students without experience (M = 3.48).

At the same time, the average level of academic confidence in completing academic tasks in English was 3.41 (SD = 0.78). The least confidence was caused by writing academic essays (M = 3.02), participating in seminar discussions (M = 3.11), and working in international project teams (M = 3.17).

The subjective assessment of readiness to participate in international academic exchanges was 3.36 (SD = 0.83). Only 22.3% of students reported being fully prepared to study in a foreign-language environment. However, 36.8% recognized low or insufficient readiness.

Thus, most students have English at a level sufficient to complete basic academic tasks, but have significant gaps in skills that are critical for successful participation in international academic exchanges.

To examine the relationships among linguistic readiness and psychological and educational factors, a Pearson correlation analysis was conducted. The following variables were included in the analysis:

LR — integral index of linguistic readiness; SE — self-assessment of language competence; AC — academic confidence; LA — language anxiety; STR — use of language and academic preparation strategies; EXP — previous international experience (0/1; point-biserial correlation). The results showed significant correlations between the main indicators (Table 2).

Table 2.
Correlations between main variables (n = 220)

Indicator	LR	SE	AC	LA	STR	EXP
LR	1	.48***	.52***	−.41***	.33***	.29***
SE	.48***	1	.57***	−.36***	.31***	.22**
AC	.52***	.57***	1	−.45***	.28***	.26***
LA	−.41***	−.36***	−.45***	1	−.19**	−.11
STR	.33***	.31***	.28***	−.19**	1	.17*
EXP	.29***	.22**	.26***	−.11	.17*	1

Significance marks:*p* < .05*, **p** < .01, ***p** < .001.

Linguistic readiness (LR) had a strong positive relationship: with academic confidence (r = .52), with self-assessment of language skills (r = .48), with learning strategies (r = .33), with international experience (r = .29). Language anxiety (LA) was negatively correlated with LR (r = −.41), with academic confidence (r = −.45).

Thus, students with international experience have higher LR, SE, AC indicators, but the relationship with anxiety is weak and statistically insignificant (See Figure 2).

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Figure 2. Regression Coefficients (β)

Regression analysis of predictors of linguistic readiness made it possible to show factors that influence the linguistic readiness of higher education applicants. The regression model included 5 predictors: academic confidence (AC); self-assessment of language competence (SE); language anxiety (LA); learning strategies (STR); previous international experience (EXP).

Outcome variable: integral index of linguistic readiness (LR).

Table 3.
Multiple linear regression for predicting linguistic readiness

Predictor	B	SE B	β	t	p
Constant	21.84	4.73	—	4.62	<.001
Academic Confidence (AC)	0.87	0.18	.45	4.78	<.001
Self-Esteem (SE)	0.54	0.21	.24	2.61	.010
Language Anxiety (LA)	−0.71	0.19	−.29	−3.62	<.001
Strategies (STR)	0.42	0.16	.18	2.63	.009
International Experience (EXP)	3.48	1.21	.17	2.87	.005

Model indicators: $R = .63$, $R^2 = .40$, Adjusted $R^2 = .38$, $F(5, 214) = 28.97$, $p < .001$.

Thus, academic confidence is the strongest predictor (β = .45). Language anxiety has a significant adverse effect (β = −.29).

Self-rated language competence is also a significant positive predictor (β = .24).

Learning strategies affect LR. Still, their effect is moderate (β = .18). Previous international experience positively and independently affects the level of linguistic readiness (β = .17).

Overall, the model accounted for 40% of the variance in the linguistic readiness score. This is a high figure for educational psychology research.

The main difficulties in developing linguistic skills are divided into several groups of difficulties: linguistic, psycho-emotional and academic-organizational. First, the majority of students showed insufficient development of key pre-academic language skills necessary for studying abroad.

Most participants noted difficulties with such skills as constructing a logically structured essay (52.7%); writing detailed written arguments in English (48.9%) and using a formal academic style (44.6%).

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This is consistent with the results of the test, in which academic writing had the lowest average scores (M = 57.1).

More than a third of students (>35%) indicated that they had difficulties participating in discussions in English and presenting the results of their work in English.

Also noticeable is insufficient academic vocabulary. In particular, 44.1% of participants indicated that they lacked professional and academic vocabulary, which is important for understanding lectures and scientific texts.

Analysis of Language Anxiety indicators and open-ended responses of participants indicated a significant role of emotional factors in the formation of linguistic readiness. At the same time, 39.5% of respondents reported that they felt a pronounced fear of making mistakes when communicating in English.

Students with high anxiety had lower test results (M = 56.3) compared to students with low anxiety (M = 68.7). The correlation between anxiety and readiness was significant and negative ($r = -.41$, $p < .001$).

Fear of not understanding the lecture or the teacher is also important. For example, 34% of participants indicated that this is a major barrier for them. Academic Confidence was average (M = 3.41), and 27.8% of participants felt “not confident enough to study abroad”. Academic and organizational barriers were also present. In particular, 42% of students reported that they did not have regular practice at university. Limited access to native speakers was also noticeable. In particular, 38% indicated that they lacked real practical communication with native English speakers. Importantly, there was a marked inequality in access to language courses among students: 28% of participants said that they could not afford additional courses that would increase their readiness.

The study aimed to identify strategies that students use to improve their English that do not depend on university resources.

The most common individual strategies included the use of Online platformsCoursera, BBC Learning English, YouTube - 64.5% and the development of academic writing through templates and samples - 41.8%. At the same time, 38.2% used AI-tools for practice (grammar check, writing training).

Reading academic texts in English was used by 36.4% AI-based writing assistants are popular, which students indicate as “useful for structuring written work and correcting stylistic errors”.

Social and interactive strategies included participation in conversation clubs (42.7%), tandem learning (27.3%), participation in international projects and online hackathons (19.5%) and joint completion of tasks with stronger students (32.3%).

However, as the open-ended data indicated, access to such strategies is uneven: “We need more speaking practice with foreigners. We practice pronunciation only in class once a week.”

“I don’t have anyone to practice real English with.”

The analysis showed that universities provided only partial support for academic and language readiness.

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The most frequently available institutional mechanisms were: English for Academic Purposes (EAP) courses – 28.6% of students confirmed their availability; English for Academic Writing courses – 20.9%; pre-departure orientation modules – only 14.5%; mentoring or consultations with international program coordinators – 26.4%; access to international educational platforms (Canvas, Coursera, FutureLearn) – 33.2%. Students report that institutional support is useful, but fragmented.

Table 4.
Strategies Used by Students and Universities to Increase Linguistic and Academic Readiness (N = 220)

Strategy Category	Actions / Tools	% of students who use	Strategy Type
Individual	Online courses, YouTube, self-education	64.5%	Individual
	AI tools (writing check, practice)	38.2%	Individual
	Reading academic texts	36.4%	Individual
	Maintaining your own glossaries	33.1%	Individual
Social / interactive	Speaking clubs	42.7%	Social
	Tandem learning	27.3%	Social
	Working in groups with stronger students	32.3%	Social
	Online international projects	19.5%	Institutional
Institutional	EAP courses	28.6%	Institutional
	Academic writing courses	20.9%	Institutional
	Mobility preparation modules	14.5%	Institutional
	Coordinator consultations	26.4%	Strategy Type
	Access to international platforms	33.2%	Individual

Based on correlation analysis, it was found that the indicator "intensity of strategy use" (STR) showed a positive relationship with linguistic readiness ($r = .33$, $p < .001$), self-assessment of language competence ($r = .31$, $p < .01$) and academic confidence ($r = .28$, $p < .01$). Thus, active students who worked independently on the language and used various tools indicated higher readiness for the international academic environment.

The aim of the proposed study was to conduct a comprehensive analysis of the linguistic readiness of Ukrainian university students to participate in international academic exchanges. It was also proposed to focus on several tasks: to assess the level of readiness, identify existing barriers, and describe individual and institutional strategies.

The proposed results found that the average integral indicator of linguistic readiness (62.4 out of 100) belonged to functional indicators that differ from the academic maturity level. A small proportion of students with a high level (18.6%) and a significant proportion with a low level (24.6%) indicated a pronounced stratification within the sample. The advantage in academic reading ($M = 68.2$) and the lag in academic writing ($M = 57.1$) also correspond to the results of other studies, since writing is recognized as a more complex skill in learning a foreign language. The researchers indicated that for most language learners, writing was the most problematic area, even more so than oral communication, which also involved individual expressions or gestural mimicry (O'Dowd & Dooly, 2020). Similarly, studies have shown that ESL/EFL students most often had difficulties with text organization, coherence, academic style, and working with sources (Neves & Barbosa, 2020; Arroba Muñoz et al., 2025; Polyezhayev et al., 2024).

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The results obtained in the article regarding the weak development of academic writing are consistent with more recent work, in which academic "writing readiness" includes vocabulary, grammatical complexity, structure, formatting, and time management. It is these identified components that have been most vulnerable among students who have learned English as a foreign language. The excess of self-esteem (M = 3.62) over objective test results is also consistent with other scientific data on the inaccuracy of metacognitive assessments of one's own language competence in student environments, especially when feedback on academic writing is absent (Costa & Canen, 2021).

The results identified three large groups: linguistic, psycho-emotional, and academic-organizational difficulties. Linguistic difficulties (problems with structured essays, argumentation, formal style, participation in discussions, presentations, and lack of academic vocabulary) practically repeated the research picture described in scientific works from the Asian region. In particular, the prevalence of complaints about limited vocabulary, limited repertoire of grammatical structures, etc., was confirmed. Language anxiety as a psychological barrier clearly coincided with the classical conceptualizations of foreign language anxiety, which were proposed by individual researchers (Chiappa & Finardi, 2021; Kaya, 2021; Mushyrovska et al., 2022). It was also established that anxiety worsened the functioning of working memory, reduced cognitive resources. Academic-organizational barriers included irregular language practice, limited contact with native speakers, and financial restrictions for additional courses. This was consistent with the work of other scholars, who identified, in particular, "structural inequality" in access to language resources (Souza, 2023; Kulichenko et al., 2018).

The identification of student and university strategies demonstrated the superiority of individual self-regulatory strategies (online courses, YouTube, self-education, use of AI tools, etc.). This confirmed the findings of other researchers, who showed that it was the systematic use of self-regulatory strategies that enhanced language self-efficacy (Moore et al., 2021 Miškeljin et al., 2025). Social-interactive strategies were consistent with the findings on the role of collaboration, authentic communication, and "communities of practice" for the development of language competence and academic confidence. At the same time, university strategies are less developed than in many universities in Western Europe or North America (Leal et al., 2022). EAP courses, academic writing courses, etc., are less popular here and do not have such an impact. The proposed results found that the obtained regression model (R^2 = .40) depends on a combination of psychological factors (academic confidence, anxiety), cognitive-metacognitive (self-esteem, strategies), and experience (international mobility). This result was fully consistent with existing modern models that linked L2 productivity and readiness for foreign language interaction. Several studies have shown that self-efficacy is a powerful indicator of learning behavior (Leal et al., 2024; Zavalniuk et al., 2022). The results obtained complemented these models, as they integrated five components (confidence, self-esteem, anxiety, intensity of strategy use, and international experience) into a single empirical scheme.

The results obtained also had important practical implications specifically for Ukrainian higher education institutions operating within the European Higher Education Area and actively involved in academic mobility programs, primarily Erasmus+. The identified gap between the formal level of English proficiency (B1–B2) and the real academic language readiness of students indicated the importance of reorienting language training (Zayachuk, 2025). First of all, the results confirmed the importance of systematically implementing academic English (EAP) courses and academic writing as mandatory or optional components of educational

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programs, especially for students in 2–4 years of undergraduate studies and the initial level of master's studies. It was also found that the high level of language anxiety indicated the need to integrate psychologically oriented approaches into students' language training. For Ukrainian universities, the way out of the situation should be to combine language courses with training in academic confidence. The predominance of individual self-regulatory strategies over institutional ones indicated a structural deficit of university support. In Ukrainian realities, this highlighted the need to develop institutional mechanisms for language support for mobility participants, in particular language centers, conversation clubs, tandem programs, etc. as auxiliary learning tools. The latter thesis has been repeatedly proposed by other researchers (Torubara, 2025; Wingrove et al., 2025). In general, the proposed results are important for use by international departments of universities as an analytical basis for the selection and preparation of candidates for academic mobility.

The methodology used in the study, however, has some differences that need to be paid attention to during the subsequent interpretation of the results. First of all, the sample included higher education applicants from only a few Ukrainian universities. This does not allow us to reflect the full diversity of student environments in higher education institutions. Therefore, this may create unevenness in the study, since students of the humanities could be represented more than students of technical fields. Also, correlation analysis allowed us to describe the relationships, but did not allow us to form cause-and-effect relationships. Conclusions. Accordingly, some of the findings regarding academic confidence and linguistic readiness should be viewed as pilot.

Conclusions

Thus, most participants had an average level of readiness: high results in reading and understanding educational materials, however, they had difficulties in academic writing, oral academic speaking and using English in practical academic situations. Students' self-esteem was often overestimated in relation to their actual test results. The work identified three groups of key barriers: linguistic (problems with academic vocabulary, inability to participate in oral discussions in English), psycho-emotional (language anxiety, fear of making mistakes) and organizational (fragmentary teaching of EAP, insufficient level of practical modules for preparing for mobility). Important strategies that students use autonomously are: online platforms and self-education; reading academic texts; participation in speaking clubs; tandem learning; use of AI to support academic writing. The regression analysis model indicated that the main predictors of linguistic readiness are academic confidence, language anxiety, self-esteem and learning strategies.

At the same time, given the limited financial and organizational resources typical of many Ukrainian universities, the results of the study showed the possibility of implementing low-cost strategies to increase language readiness. Such strategies would include integrating elements of academic English (EAP) into existing academic disciplines without creating separate courses. An effective tool in conditions of limited resources would also be the systematic use of open educational resources, free online platforms and digital tools, in particular AI tools to support academic writing.

The results of the multivariate analysis determined that: academic confidence is the strongest positive predictor; language anxiety significantly reduced readiness; the

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intensity of the use of strategies increases the level of readiness; previous international experience also contributes to higher indicators.

Based on the results obtained, directions for improving students' preparation for academic mobility are proposed. It is indicated that universities should introduce systemic EAP (academic reading, writing, speaking) programs and create a mandatory mobility preparation module. For students, it is worth increasing the intensity of individual strategies: academic reading, written practices, the use of AI and reducing anxiety through controlled exposure (practice-based speaking), reflection and group work.

Thus, the linguistic readiness of Ukrainian students for international academic exchanges develops based on several interrelated factors: the level of academic language skills, emotional and psychological background and systematic university support. Despite the average level of readiness, most students did not possess a sufficient set of academic skills necessary for effective participation in international educational programs. Therefore, there is a need for targeted, systematic and multidimensional language training, consisting of individual and institutional strategies.

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Original Article

The digital educational environment as a predictor of future teachers' inclusive competence: A mediation analysis

El entorno educativo digital como predictor de la competencia inclusiva del futuro docente: un análisis de mediación

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Abstract

This study investigates the characteristics of the digital educational environment that influence the development of teachers' inclusive competence. Utilizing a quantitative, correlational-regression design with mediation analysis, the research involved 214 undergraduate students from pedagogical specialties in Ukraine. Standardized instruments based on DigCompEdu and UNESCO frameworks were employed to assess the digital environment's supportive potential and students' inclusive competence. Results indicate that participants possess an above-average level of inclusive competence, particularly in value-motivational aspects. Statistical analysis reveals that a supportive digital context (β = 0.36) and the accessibility of digital services (β = 0.24) are significant predictors of inclusive competence. Furthermore, mediation analysis confirms that the accessibility of digital services partially mediates the relationship between a supportive environment and inclusive competence (indirect effect = 0.16). The findings suggest that higher education institutions should prioritize creating supportive, accessible digital ecosystems to foster future teachers' readiness for inclusive education effectively.

Keywords: accessibility of digital services, digital educational environment, inclusive competence, professional competence of teachers, support.

Resumen

Este estudio investiga las características del entorno educativo digital que influyen en el desarrollo de la competencia inclusiva del profesorado. Utilizando un diseño cuantitativo de regresión correlacional con análisis de mediación, la investigación involucró a 214 estudiantes universitarios de especialidades pedagógicas en Ucrania. Se emplearon instrumentos estandarizados basados en los marcos DigCompEdu y UNESCO para evaluar el potencial de apoyo del entorno digital y la competencia inclusiva del alumnado. Los resultados indican que los participantes poseen un nivel de competencia inclusiva superior a la media, especialmente en aspectos de motivación de valores. El análisis estadístico revela que un contexto digital de apoyo (β = 0,36) y la accesibilidad a los servicios digitales (β = 0,24) son predictores significativos de la competencia inclusiva. Además, el análisis de mediación confirma que la accesibilidad a los servicios digitales media parcialmente la relación entre un entorno de apoyo y la competencia inclusiva (efecto indirecto = 0,16). Los hallazgos sugieren que las instituciones de educación superior deberían priorizar la creación de ecosistemas digitales de apoyo y accesibles para fomentar eficazmente la preparación del futuro profesorado para la educación inclusiva.

Palabras clave: accesibilidad de los servicios digitales, entorno educativo digital, competencia inclusiva, competencia profesional del profesorado, apoyo.

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Introduction

In the current conditions of transformation in the field of education, digitalization has become an important factor. In fact, it has determined the possibilities of accessibility, equality and inclusion in the educational process. The digital educational environment was understood as a set of technological tools, which today has turned into a specific “ecosystem” that combines individualization of learning, adaptation of educational materials to the needs of different categories of education seekers, overcoming barriers that traditionally made access to quality education for education seekers with special needs more difficult. Despite significant progress in the development of inclusive education, modern scientific discussions emphasize that technological innovations are not fully integrated into the educational process. Under such circumstances, their impact on the real level of inclusion remains poorly studied.

The scientific problem underlying the proposed study is the insufficient theoretical and empirical substantiation of the role of the digital educational environment, which was a systemic factor in the development of inclusive education. In particular, some studies noted that digital tools were capable of ensuring the accessibility of educational content, supporting differentiation and adaptability of the educational process (Jones & Lomas, 2025; Rodríguez Zidán et al., 2025). However, the instruments of their influence on the structure and effectiveness of inclusive practices have been studied only fragmentarily (Zicari, 2022; Sharma & Sengupta, 2023). Under such circumstances, additional attention would be required to the issue of the readiness of all participants in the educational process (teachers, administrators, students and their parents) to use digital solutions in the context of deepening inclusive learning (Tomczyk et al., 2021). An analysis of the available scientific literature demonstrated the contradictions of conclusions regarding the extent to which digital environments actually expand the possibilities of inclusive interaction (Masoumi & Noroozi, 2023). There were also opposing assessments indicating the possibility of a negative impact of digitalization.

The study was aimed at determining the main characteristics of the digital educational environment that affect the development of inclusive competence of teachers.

RQ1. What is the level of inclusive competence of future teachers, and how much does it vary in its cognitive, value-motivational, and activity aspects?
RQ2. What characteristics of the digital educational environment are associated with the formation of students' inclusive competence?
RQ3. What elements of the digital educational environment are statistically significant predictors of inclusive competence of future teachers?
RQ4. Does the availability of digital services mediate the effect of a supportive environment on inclusive competence?

Literature Review

In modern studies, the digital educational environment is considered as an important factor in the development of teachers' professional competencies. Scientists have especially paid attention to the acquisition of inclusive competence (Göltl et al., 2024; Hurtado-Mazeyra et al., 2022). In particular, the analysis of reports by international organizations (UNESCO, ECLAC) emphasized that the digitalization of education has significantly expanded access to education for students with different needs (Wyss et al., 2022). However, this is only possible if teachers are

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sufficiently trained and there is a high-quality digital environment in educational institutions.

Studies that have been devoted to the characteristics of digital educational environments (for example, Moodle or other VLE) have shown that the accessibility of the platform, the structure of the materials provided, the use of multimedia and adaptive tools have influenced the engagement and success of students (Karakasidi et al., 2024). Accordingly, this is also relevant for students with special educational needs (Chiner et al., 2024). However, some researchers have emphasized that technology alone does not guarantee inclusion (Ghoneim et al., 2024). Teachers who are able to adapt digital content to modern pedagogy and choose appropriate support methods for students with disabilities will continue to play a crucial role. At the same time, it is worth noting that interest has grown in the concept of digital competence of teachers as a set of skills for working with digital resources, communication, content creation and organization of online learning. Such studies have shown the emergence of strong links between the level of digital competence and the readiness of teachers to work in an inclusive environment (Isoda et al., 2021). In particular, some studies have shown that teachers with higher digital literacy are more likely to use inclusive practices and have a more positive attitude towards working with different groups of students. This thesis has also been repeatedly confirmed in other scientific publications, which is an important component of the proposed study.

In Latin American countries, where digital inequality is more pronounced, studies have confirmed that the digital environment is adapted to support inclusion, creating solutions to overcome additional barriers (Navas-Bonilla et al., 2025; Reyes & Gurubel-Tec, 2024). Reports from international organizations have shown that the level of digital competence of teachers in different regions varies significantly (Vásquez et al., 2021; Sarubbi-Baltazar et al., 2025). For the South American region, this has affected the quality of work in virtual platforms and the ability to adapt learning to the needs of different learners. In particular, several empirical studies have found that participation in learning in a digital environment significantly contributed to the development of important skills in future teachers - interaction, reflection, emotional responsiveness - which were a key part of inclusive pedagogical practice (Salas-Pilco et al., 2022).

In conclusion, the analysis of the scientific literature showed that the digital educational environment contributed to the development of inclusive approaches, the role of the teacher was key, since it was she who determined whether the digital environment became accessible and flexible, the development of teachers' digital competence was directly related to their ability to implement inclusive practices (Valero-Tapia et al., 2024; Velandia Rodriguez et al., 2022). Therefore, these areas substantiated the relevance of studying the connection between the digital educational environment and the development of inclusive competence of teachers. At the same time, despite the proposed analysis of the digitalization of education and inclusive pedagogy, scientific research demonstrated the presence of several important research gaps. First of all, it is worth pointing out that the analysis of teachers' digital competence and inclusive practices separately, while the direct relationship between these two components has not been sufficiently studied. There is little research that addresses the digital educational environment as a factor in changing teachers' inclusive competence. Another notable gap is the small number of proposed tools and methodologies that can be used to measure teachers' inclusive competence when working in digital or blended learning formats.

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Methodology

Research design

The study is based on a quantitative paradigm using correlational regression design and mediation analysis. The choice of this methodology is due to the aim of the work - to identify digital characteristics as predictors (prognostic factors) of inclusive competence. Theoretically, the work fits into the concept of a digital ecosystem of education, where technological tools are considered as a means of ensuring accessibility and individualization of learning. The study fills a scientific gap by connecting two previously separate areas: digital competence within the DigCompEdu framework and inclusive competence according to UNESCO standards.

The adapted instruments are structured according to international domains: environmental parameters (support, intensity, accessibility) and competence components (cognitive, value, activity).

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Within the design, the features of the digital educational environment were assessed (independent variable): 1. availability of digital resources and services; 2. frequency and intensity of use of digital technologies in the educational process; 3. students' subjective perception of the supportive/inclusive nature of the digital environment.

The inclusive competence of future teachers was also assessed (dependent variable):

1. Cognitive component (basic knowledge about inclusion); 2. value-motivational component (attitude to inclusion, willingness to work in an inclusive environment); 3. activity component (self-assessment of the ability to adapt tasks and use modern technologies).

Participants

The participants were selected from higher pedagogical education institutions in Ukraine, which at the time of data collection were experiencing active digitalization and widespread implementation of inclusive education. All participants studied at higher pedagogical education institutions that used LMS platforms, distance and blended learning tools, and implemented educational components related to inclusive teacher training. This institutional context should be taken into account when interpreting and generalizing the results.

The study involved 214 students of pedagogical specialties who study educational programs of preschool and primary education, as well as special/inclusive education in higher education institutions of Ukraine.

Educational level of participants: 2–4 years of bachelor's degree (future educators of preschool education institutions, primary school teachers, teacher assistants / special educators).

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Age was correlated in the range of mainly 18–23 years (average age about 20 years).

The study was dominated by women, which is typical for pedagogical institutions (See Table 1).

Table 1.
Characteristics of Study Participants (N = 214)

Variable	Category	n	%
Gender	Female	192	89.7%
	Male	22	10.3%
Age	18–19 years	74	34.6%
	20–21 years	102	47.7%
	22–23 years	38	17.7%
Specialization	Preschool Education	96	44.9%
	Primary Education	78	36.4%
	Special / Inclusive Education	40	18.7%
Year of Study	2nd year	64	29.9%
	3rd year	92	43.0%
	4th year	58	27.1%
Experience with Digital Learning (self-reported)	Low	32	15.0%
	Medium	128	59.8%
	High	54	25.2%
Previous courses on inclusion	Yes	138	64.5%
	No	76	35.5%

Inclusion criteria for the sample:

1. Studying in pedagogical specialties that involve working with children of preschool or primary school age
2. Experience in teaching using the university's digital educational environment (learning on LMS platforms, using video conferences, electronic courses, etc.) for at least one semester.
3. Voluntary consent to participate in the study and fill out an online questionnaire.

Participants were recruited based on the use of convenience sampling. The main link to the questionnaire was distributed through academic groups on social networks and e-mail of curators/teachers. Participants were informed about the objectives of the study, voluntary participation, anonymity and confidentiality of the data obtained.

Instruments

To determine the impact of the digital educational environment on the development of inclusive competence of future teachers, a set of standardized and adapted questionnaires was used. The instrument included two blocks: (1) scales measuring the parameters of the digital environment, and (2) scales of inclusive competence.

To assess the digital educational environment, an author-adapted instrument was used. This instrument was formed based on DigCompEdu components and modern models of the digital ecosystem in education. The scale consisted of three subscales:

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1. Supporting potential of the digital environment (Scale: 1–5; α = 0.84). The main examples of statements related to the following areas:

A) "Digital platforms ensure the accessibility of educational materials for all applicants."
B) "Electronic resources are adapted for students with different educational needs."

2. Intensity of use of digital technologies in education (Scale: 1–5; α = 0.81). The main examples of statements related to the following areas:

    1. "I regularly complete educational tasks in an online environment."
    2. "My university systematically uses digital tools to support the educational process."

Accessibility and functionality of digital services (Scale: 1–5; α = 0.79). The main examples of statements related to the following areas:

"The university LMS is convenient and easy to use."
"Interactive tools (forum, chats, video conferences) work stably."

The total scores made it possible to describe the level of development of the digital educational environment and its potential for the formation of students' professional competencies.

The assessment of inclusive competence of future teachers was based on the use of a special questionnaire on inclusive competence, which was compiled on the basis of the UNESCO international framework and modern Ukrainian standards for professional training of teachers.

It included three interrelated subscales.

1. Cognitive component (knowledge) (Scale: 1–5; α = 0.86).

The main examples of statements related to the following areas:

A) "I understand the principles of organizing an inclusive educational environment."
B) "I have knowledge about the educational needs of children with SEN and digital support tools."

2. Value-motivational component (attitude) (Scale: 1–5; α = 0.88). The main examples of statements related to the following areas:

    1. "I consider inclusive education to be an important direction of modern pedagogy."
    2. "I have a positive attitude towards the use of digital technologies in working with children with different educational needs."

3. Activity component (practical skills) (Scale: 1–5; α = 0.83) The main examples of statements related to the following areas:

    1. "I can adapt educational materials using digital tools."
    2. "I can organize support for students with SEN in a distance or blended format."

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The overall indicator of inclusive competence was calculated as the integral sum of the three subscales.

Data collection procedure

The instruments underwent a preliminary content validation procedure. In particular, the expert assessment was conducted by six specialists (with 8–20 years of experience) in the fields of pedagogy, inclusive education, and digital educational technologies. The experts assessed the relevance, clarity and compliance of the items with the research objectives on a 4-point scale.

Items with a compliance coefficient below 0.78 were revised or removed. Based on the results of the assessment, the wording of 7 items was clarified, and the final version of the instrument demonstrated an appropriate level of internal consistency (α = 0.79–0.88).

The data collection procedure was staged. At the first stage, students were provided with information about the purpose, methods and voluntariness of participation. At the same time, all participants confirmed their informed consent. At the next stage, an online survey was conducted. The questionnaire was created in Google Forms. The questionnaire included all the questionnaires mentioned above. The questionnaire took approximately 20–25 minutes to complete. Recruitment was carried out through academic groups, corporate email, and university learning platforms. All data were collected over 3 weeks until the required sample size (n = 214) was reached.

Data analysis

Data processing and analysis were carried out using SPSS 28 software. The analysis was carried out in several stages. In particular, the initial data processing was carried out first.

Before conducting statistical procedures, the following was performed:

checking for the presence of missing values and their correction (less than 2% of cases, filling in according to the average value of the corresponding scale). The homogeneity of variances was also checked using the Levene method. The next stage involved the use of descriptive statistics. In particular, for all main variables, the following were calculated:

mean value (M), standard deviation (SD), minimum and maximum, 95% confidence intervals. Pearson's coefficient (r) was used to establish relationships between the characteristics of the digital educational environment and the level of inclusive competence. The statistical significance level was set at p <0 .05. Regression analysis was also used.

The multiple linear regression model consisted of:

Dependent variable: 1. general indicator of inclusive competence (or separately - cognitive, motivational, activity components).

Independent variables: 1. supporting potential of the digital environment, 2. intensity of use of digital technologies, accessibility, 3. functionality of digital services.

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Regression made it possible to indicate which aspects of the digital educational environment have the greatest influence on the formation of inclusive competence of students. The method of comparative analysis was also used. These methods made it possible to establish the level of inclusive competence in students with different experience of using digital technologies.

Results and Discussion

Results

The analysis of descriptive statistics indicated the general level of inclusive competence of future teachers. The general integral indicator of inclusive competence demonstrated an above-average level of formation (M = 3.84; SD = 0.52). Therefore, there are sufficiently positive attitudes to promote inclusive competence.

The cognitive component, which indicated students' knowledge of the principles of inclusion, legislative norms and features of supporting children with special needs, had a moderately high level (M = 3.78; SD = 0.58). Therefore, students are generally well-versed in the theoretical aspects of inclusive education. The value-motivational block had the highest indicators among all subscales (M = 4.02; SD = 0.63). Students expressed a positive attitude towards inclusive education and recognized its necessity. The increased role of this aspect indicated a humanistic position and high internal motivation to support inclusive practices.

The activity aspect was the lowest among the three components (M = 3.72; SD = 0.54). Despite the positive results, it is the practical skills of students that need further development (See Figure 1).

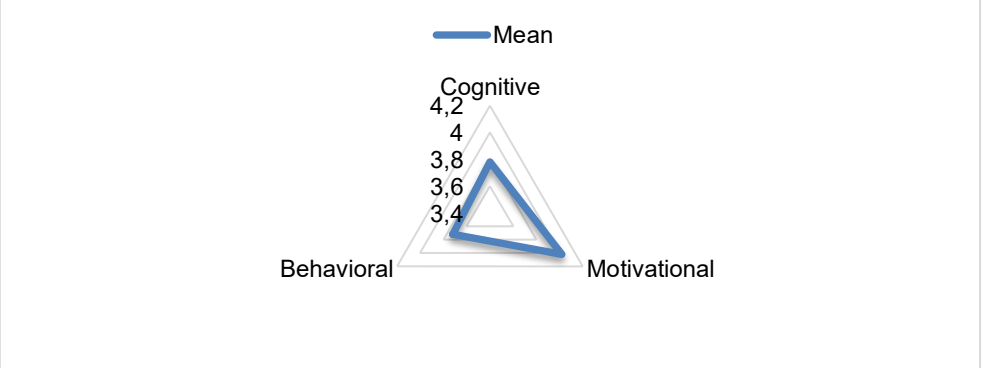


Figure 1. Inclusive Competence Components (Radar Chart)

An important direction of this research was to determine the characteristics of the digital educational environment that are associated with inclusive skills. For this purpose, a correlation analysis was carried out between the 3 components of the digital educational environment (supportive potential, intensity of use of digital technologies, availability of digital services) and the general level of inclusive competence of students. Accordingly, moderate and strong relationships were obtained between all characteristics of the digital educational environment and the level of inclusive competence of students. In particular, the strongest relationship was established between the support of the digital environment and general inclusive competence ($r = 0.46$, $p < 0.001$). Thus, students who studied in a more

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friendly and adaptive digital environment had a higher level of readiness for inclusive pedagogical activity (Kulichenko et al., 2018).

The second strongest relationship was between the availability of digital services or technologies and inclusive competence ($r = 0.39$, $p < 0.001$). Thus, the quality of the LMS, interactive platforms, and the ability to access materials for students with different needs improved the level of students' professional skills.

The smallest, but still significant, relationship was between the intensity of use of digital technologies and inclusive competence ($r = 0.28$, $p < 0.01$). Thus, the frequency of use of digital tools is less important than their supportive and adaptive potential (See Table 2).

Table 2.
Correlation Matrix Between Digital Environment Characteristics and Inclusive Competence (N = 214)

Variables	1	2	3	4
1. Supportive Digital Environment	—	0.34**	0.48***	0.46***
2. Intensity of Digital Use	0.34**	—	0.29**	0.28**
3. Accessibility of Digital Services	0.48***	0.29**	—	0.39***
4. Inclusive Competence (Total)	0.46***	0.28**	0.39***	—

Note. Pearson's r coefficients reported; $p < 0.01$, *$p < 0.001$.

Multiple linear regression allowed us to identify the main characteristics of the digital educational environment that are predictors of inclusive competence. The model was statistically significant ($F(3, 210) = 44.78$, $p < 0.001$) and explained 39% of the variation in students' inclusive competence ($R^2 = 0.39$). The strongest predictor was a supportive digital context ($\beta = 0.36$, $p < 0.001$). This therefore indicated the importance of a friendly, adaptive and pedagogically structured digital environment. The availability of digital services was also an important predictor ($\beta = 0.24$, $p = 0.002$). The intensity of digital technology use had the lowest effect. However, this effect was significant ($\beta = 0.12$, $p = 0.037$). Thus, the quality of the digital educational environment plays a significant role in shaping the inclusive competence of future teachers (See Table 3 and Figure 2).

Table 3.
Multiple Regression (N = 214)

Predictor	B	SE	β	t	p	95% CI	VIF
Constant	1.12	0.18	–	6.21	< 0.001	[0.77, 1.47]	–
Supportive Digital Environment	0.41	0.07	0.36	5.78	< 0.001	[0.27, 0.55]	1.42
Accessibility of Digital Services	0.28	0.09	0.24	3.21	0.002	[0.11, 0.45]	1.39
Intensity of Digital Use	0.11	0.05	0.12	2.10	0.037	[0.01, 0.21]	1.18

$R^2 = 0.39$; Adjusted $R^2 = 0.38$; $F(3, 210) = 44.78$, $p < 0.001$

Figure 2 shows the contribution of three characteristics of the digital learning environment—supportive context, availability of digital services, and intensity of digital use—to predicting students' level of inclusive competence. The calculated β-coefficients indicated that the supportive digital environment was the strongest predictor, followed by the availability of digital services.

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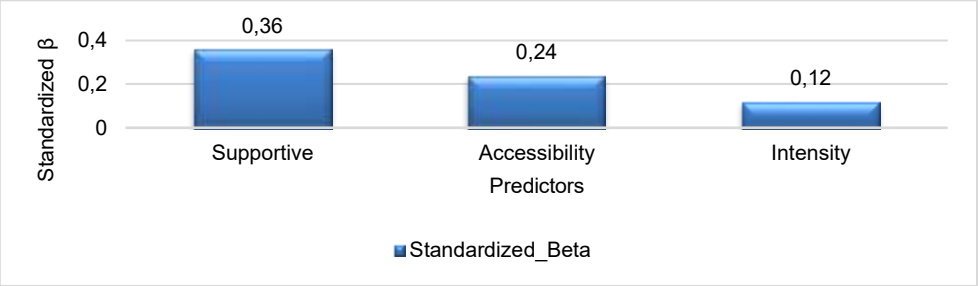


Figure 2. Standardized Regression Coefficients.

To establish the impact of a supportive digital environment on students' inclusive competence, a mediation analysis was also conducted using the "Supportive → Accessibility → Competence" model. Thus, a supportive digital environment significantly predicted the accessibility of digital services (β = 0.48, p < 0.001). At the same time, the accessibility of digital services became a significant predictor of inclusive competence (β = 0.28, p = 0.001).

The indirect effect was statistically significant (a × b = 0.16, 95% CI [0.07, 0.27]). This indicated partial mediation. In addition, after taking into account the mediator, the direct effect of Supportive → Competence decreased. However, it remained significant (β = 0.30, p < 0.001). This indicated a mixed, i.e. direct and mediated nature of the effect (See Table 4).

Table 4.
Mediation Analysis: Accessibility is a Mediator between Digital Enabling Environment and Inclusive

Path	B	SE	β	t	p	95% CI
a: Supportive → Accessibility	0.52	0.08	0.48	6.57	< 0.001	[0.37, 0.67]
b: Accessibility → Competence	0.31	0.09	0.28	3.44	0.001	[0.11, 0.45]
c: Total Effect (Supportive → Competence)	0.46	0.07	0.46	6.52	< 0.001	[0.32, 0.60]
c′: Direct Effect	0.30	0.08	0.30	3.75	< 0.001	[0.14, 0.46]
Indirect Effect (a × b)	0.16	—	—	—	0.004*	[0.07, 0.27]

Note: *The indirect effect is significant when the CI does not include zero.

Therefore, data from correlation, regression, and mediation analyses consistently indicated that the quality of the digital educational environment, in particular, its supportive nature and the accessibility of digital services, play an important role in developing the inclusive competence of future teachers.

Discussion

This study was aimed at determining the impact of the characteristics of the digital educational environment on the development of inclusive competence of future teachers. The results obtained made it possible to identify the main mechanisms for the formation of inclusive skills within the framework of the digitalization of education.

The first research question concerned the determination of the general level of inclusive competence of future teachers and its components. The results indicated that in general, the level of inclusive competence of students was at the average and above average level. This situation corresponds to the general current trends in the training of teachers focused on inclusive values (Utami et al., 2025;

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Skantz-Åberg et al., 2022). At the same time, it was indicated that the highest level was achieved by the value-motivational and cognitive components. However, the activity component was weaker in this system.

This is consistent with previous works, which indicated that students of pedagogical specialties had positive attitudes towards the development of inclusion (Rodrigues de Souza Fausto et al., 2021; Okoye et al., 2022). However, the authors also indicated that they needed more opportunities for the practical application of inclusive strategies (Palacios-Rodríguez, 2024; Martín Párraga et al., 2022). Thus, the results of our sample confirmed the existing trend. It is proven that values and knowledge are formed faster than practical skills.

The next task was aimed at identifying the main characteristics of the digital educational environment, which are associated with the inclusive competence of students. In particular, the conducted correlation analysis indicated that all three characteristics of the digital environment had statistically significant relationships with inclusive competence. However, the strongest relationship was recorded between the supportive digital environment and inclusive competence ($r = 0.46$). Thus, such phenomena as friendliness, pedagogical support, intuitiveness of interfaces and interaction of the teacher with students affected the level of readiness for inclusive practice.

Similar results are also presented in other works. In particular, the authors proved that a digital environment with a high level of support allows for the development of cooperation, self-regulation and a positive learning experience (Samaniego López et al., 2025; Dolezal et al., 2025; Bobro, 2024). Such data also correlate with the development of inclusive values (Marcus-Quinn, 2025; Nogueira et al., 2022).

The accessibility of digital services was also a significant factor ($r = 0.39$). The idea that technical accessibility and universal design contribute to equal access to education has also been supported in other works. The lowest association was between the intensity of digital technology use and inclusive competence ($r = 0.28$). However, it was statistically significant. This important observation was consistent with other scholars who indicated that the frequency of technology use did not guarantee the quality of inclusive training. The third question was aimed at identifying the characteristics of the digital educational environment that influenced the formation of inclusive competence. The results of multiple regression showed that a significant predictor of inclusive competence was a supportive digital context ($\beta = 0.36$). The second strongest was the accessibility of digital services ($\beta = 0.24$). The results also indicated that inclusion is developed through a well-formed educational digital environment. In general, the results are consistent with the works of other scholars who emphasized that inclusion and digitalization interacted based on an accessible and supportive digital space (Kasperė & Liubinienė, 2022; Jogezai et al., 2023). The conducted mediation analysis indicated a partial but statistically significant mediation. Thus, a supportive digital environment influenced inclusive competence through increasing the accessibility of digital services. The indirect effect was 0.16 (95% CI [0.07, 0.27]). This confirmed the model according to which it is necessary to first form a supportive, structured digital environment. This in turn will lead to increasing the accessibility of materials, which will ultimately enhance the development of inclusive skills. Therefore, the category of accessibility acted as a significant mechanism for transmitting the influence of Supportive – Competence (Basantes-Andrade et al., 2022). Similar data have been presented in other works, which indicated that the availability of digital resources is a significant factor in the development of pedagogical skills

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(Montenegro-Rueda & Fernández-Batanero, 2022; Pimentel & Miranda, 2025; Byrko et al., 2022). Therefore, the digital educational environment has become an important factor in the development of inclusive competence, as the support and availability of digital resources played a key role.

Therefore, the study showed that digital practice was often reduced to the reproductive use of technology, and little time was devoted to modeling real inclusive pedagogical situations. In the absence of practice-oriented modules, simulations or mentoring support from teachers, digital inclusive activities remain abstract for students.

The results of the mediation analysis had important implications for management decisions in higher education institutions. In particular, it was indicated that a supportive digital environment influenced the development of inclusive competence not only directly, but also indirectly. This means that administrative decisions should be aimed at creating a holistic, friendly and inclusively oriented digital ecosystem.

From a practical point of view, it is advisable for university administrations to integrate practice-oriented inclusive tasks into digital courses. It is also worth ensuring the accessibility of LMS and digital services in accordance with the principles of universal learning design so that students can practically work with accessible interfaces.

In addition, it is worth training teachers as digital mentors who can demonstrate examples of inclusive digital practices and accompany students in the process of their application. In the future, it is also worth shifting the emphasis from the frequency of technology use to the quality of pedagogical support, as the intensity of digital activity itself does not guarantee the development of inclusive competence.

Despite the results obtained, the study also had some limitations. In particular, the study was of a correlation-regression nature. This did not allow us to form causal relationships with absolute certainty. Although the mediation model was statistically confirmed, it is still based on cross-sectional data. It is also worth recognizing that the assessment of variables was based on self-assessment, which may affect subjective statements. In the future, it is planned to conduct long-term studies that will allow us to track the dynamics of the development of inclusive competence in students during the long-term use of digital technologies. This will allow us to establish the stability of the effects and the reliability of causal relationships.

Conclusions

Thus, the overall level of inclusive competence of students was quite high, especially in the value-motivational and cognitive aspects. However, the activity component remains to be formed. This indicated the need to expand practice-oriented forms of learning in the digital environment.

It was determined that the main characteristics of the digital educational environment are related to the development of inclusive skills. A supportive digital environment plays an important role for high-quality pedagogical interaction. The availability of resources and a positive learning experience were important factors in the development of inclusion.

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The results of multiple regression indicated the predictive potential of digital characteristics. In particular, the supportability and accessibility of digital services are statistically significant predictors of inclusive competence.

Finally, the mediation analysis indicated that the availability of digital services partially mediates the effect of a supportive digital environment on students' inclusive competence. Thus, a well-organized, structured, and friendly digital environment contributed to the formation of inclusive skills based on ensuring equal access to resources and adaptive opportunities.

Therefore, the results obtained have important implications for educational policy and curriculum design, as they indicate the need to strengthen practice-oriented components of digital inclusion in the training of future teachers.

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Original Article

Digital competence development of social-interaction specialists within higher education

Desarrollo de la competencia digital de los especialistas en interacción social en la educación superior

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Abstract

This study evaluates the impact of a digitally enriched educational environment on the development of digital competence among students in social-interaction specialties in higher education. A quasi-experimental design was implemented with control and experimental groups, integrating structured digital learning activities aimed at strengthening technological, cognitive, and motivational components of digital competence. Data were collected through validated diagnostic tools and analyzed using statistical procedures to determine the effectiveness of the intervention. The results indicate significant improvements in the digital competence levels of students exposed to the digitally enriched learning environment compared with those in the control group. These findings highlight the pedagogical value of systematically integrating digital environments into higher education curricula and support their role in enhancing students' readiness to operate in digitally mediated professional contexts.

Keywords: digital competence, specialists in social-interaction specialties, higher education institutions, digital platforms, artificial intelligence.

Resumen

Este estudio evalúa el impacto de un entorno educativo digital enriquecida en el desarrollo de la competencia digital en estudiantes de especialidades de interacción social en educación superior. Se implementó un diseño cuasi experimental con grupos control y experimental, incorporando actividades formativas estructuradas orientadas al fortalecimiento de componentes tecnológicos, cognitivos y motivacionales de la competencia digital. Los datos se recopilaron mediante instrumentos diagnósticos validados y se analizaron a través de procedimientos estadísticos para determinar la efectividad de la intervención. Los resultados evidencian mejoras significativas en los niveles de competencia digital de los estudiantes que participaron en el entorno educativo digital, en comparación con el grupo control. Estos hallazgos resaltan el valor pedagógico de integrar sistemáticamente entornos digitales en la educación superior y respaldan su potencial para fortalecer la preparación de los estudiantes frente a contextos profesionales mediados por tecnologías digitales.

Palabras clave: competencia digital, especialistas en especialidades de interacción social, instituciones de educación superior, plataformas digitales, inteligencia artificial.

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Introduction

The digital transformation of higher education in Ukraine has accelerated significantly in recent years, dbyriven to large-scale educational reforms, the expansion of distance and blended learning, and the increasing reliance on digital platforms for teaching, learning, and academic communication. In Ukrainian higher education institutions, learning management systems (e.g., Moodle, Google Workspace, Microsoft Teams) and cloud-based services have become integral components of the educational process. However, the rapid introduction of digital infrastructure has not been accompanied by a proportional and systematic development of students' digital competence, particularly in professionally oriented programs.

The present study was conducted at a higher education institution in Ukraine that provides professional training for students in social-interaction specialties. These specialties include fields in which professional activity is based on communication, interaction, educational support, and social engagement. Within this institutional context, digital technologies are formally integrated into the educational environment; however, institutional monitoring and preliminary diagnostic assessments revealed persistent difficulties in students' effective use of digital tools for professional and educational purposes (Guillén-Gámez et al., 2023).

Empirical diagnostic data collected at the ascertaining stage of the study provide evidence of a substantial deficit in students' digital competence. Specifically, among 124 undergraduate and graduate students, the majority demonstrated low and medium levels of digital competence across motivational, cognitive, and activity-based components. Students showed limited ability to independently use learning management systems, cloud services, specialized software, and digital communication tools in ways aligned with professional tasks. These results indicate a discrepancy between the availability of digital educational technologies and students' readiness to apply them in their professional practice.

This deficit is particularly critical in the Ukrainian higher education context, where digital technologies have become essential for ensuring continuity of education, access to learning resources, and participation in academic and professional communication. For students in social-interaction specialties, insufficient digital competence directly affects their ability to engage in collaborative work, digital documentation, online communication, and the use of digital tools for professional support and decision-making. Consequently, the identified gap represents not only a technical issue but also a pedagogical and professional training problem.

The diagnosed insufficiency of digital competence provided a direct empirical justification for the design and implementation of a pedagogical experiment. The experiment was developed as a targeted educational intervention aimed at addressing the specific needs identified in the institutional context. It included the introduction of defined pedagogical conditions, a specialized course focused on digital competence development, and a structured methodology for integrating digital technologies into professional training. The use of experimental and control groups enabled a controlled evaluation of the effectiveness of this intervention.

The scientific contribution of this study lies in its context-sensitive and experimentally validated approach to digital competence development in Ukrainian higher education. By grounding the intervention in empirical diagnostic data and institutional conditions, the study moves beyond general discussions of digitalization and provides evidence-based insights into how structured pedagogical interventions

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can enhance motivational, cognitive, and activity-based components of digital competence among students in social-interaction specialties. The findings contribute to the development of scalable models for digital competence formation that are relevant for higher education systems undergoing rapid digital transformation.

Literature Review

Recent research consistently emphasizes digital competence as a core component of professional readiness in higher education, particularly in contexts characterized by rapid digital transformation (Vuorikari et al., 2016; Cabero-Almenara et al., 2023). However, a closer examination of the literature reveals substantial heterogeneity in how digital competence is conceptualized, operationalized, and empirically assessed. While frameworks such as DigComp and TPACK provide comprehensive theoretical structures, empirical studies frequently adopt partial or fragmented interpretations of these models, focusing on selected dimensions rather than integrated competence development.

Several studies adopt a descriptive and cross-sectional approach, relying primarily on self-reported measures to assess students' or teachers' perceived digital competence (Vázquez-Cano et al., 2017; Sánchez Olavarría & Carrasco Lozano, 2021). Although these studies offer valuable insights into general trends and demographic differences, their methodological design limits their capacity to explain causal mechanisms or to evaluate the effectiveness of specific pedagogical interventions. As a result, the literature provides extensive descriptive evidence of digital competence levels but comparatively limited experimental evidence on how these competencies can be systematically developed through targeted educational strategies.

Intervention-based studies represent a smaller but methodologically more robust body of research. For example, Holguin-Alvarez et al. (2021) and Velásquez-Castro et al. (2023) demonstrate that structured digital learning activities and context-sensitive training programs can positively influence digital competence development. However, these studies often focus on specific populations (e.g., teacher education, vulnerable groups, or emergency remote teaching contexts) and are frequently embedded in short-term or crisis-driven educational settings. Consequently, their findings may not be directly generalizable to stable institutional contexts or to professionally oriented programs in social-interaction specialties.

Furthermore, comparative analysis indicates that many existing studies emphasize technological access and tool usage rather than the integration of motivational, cognitive, and activity-based components of digital competence as a unified construct (Saltos-Rivas et al., 2020; Gutiérrez-Santiuste et al., 2023). This fragmentation limits theoretical coherence and weakens the alignment between digital competence frameworks and pedagogical practice. In addition, while several authors highlight the importance of institutional and organizational factors, relatively few studies empirically examine how institutional contexts and diagnosed educational needs shape the design and effectiveness of pedagogical interventions. A critical gap in the literature concerns the lack of contextually grounded experimental studies that link diagnostic evidence of digital competence deficits with systematically designed and evaluated pedagogical interventions. Most studies either (a) document competence levels without proposing or testing structured solutions, or (b) describe innovative practices without embedding them in controlled experimental designs that allow for robust causal inference. This gap is particularly

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evident in studies conducted in Eastern European and post-Soviet higher education contexts, where large-scale digitalization processes coexist with limited empirical evidence on intervention effectiveness.

In addition, existing research tends to focus predominantly on teachers' digital competence, whereas comparatively few studies address students in social-interaction specialties, whose professional activities rely heavily on communication, collaboration, and digitally mediated interaction. This population presents specific pedagogical and professional requirements that are insufficiently addressed in the current literature.

In response to these gaps, the present study adopts an experimentally grounded, context-sensitive approach to the development of digital competence. By integrating diagnostic data, institutional conditions, and a structured pedagogical intervention, the study extends prior research in three key ways. First, it moves beyond descriptive assessments by experimentally testing the effectiveness of defined pedagogical conditions and a specialized course. Second, it operationalizes digital competence as an integrated construct encompassing motivational, cognitive, and activity-based components. Third, it contributes empirical evidence from the Ukrainian higher education context, thereby addressing a geographical and institutional gap in the existing literature.

Through this critical integration, the study positions itself not merely as an additional descriptive contribution but as an intervention-oriented investigation that advances both theoretical coherence and empirical rigor in research on digital competence development in higher education.

Research objective. To evaluate the impact of a digitally enriched educational environment on the development of digital competence among students in social-interaction specialties in higher education.

Methodology

Research Design

This study employed a quasi-experimental mixed-methods design to examine the effectiveness of digitally mediated instructional interventions in forming digital competence of specialists in social-interaction specialties in higher education institutions. The research design included pre-test and post-test measurements with experimental and control groups to ensure comparative analysis and to strengthen internal validity.

Research Context and Participants

The pedagogical experiment was conducted at a higher education institution in Ukraine within undergraduate programs in social-interaction specialties (e.g., education, social work, psychology, and management in education). The study involved undergraduate students enrolled in professionally oriented foreign-language and digital-literacy courses.

Participants were assigned to an experimental group (EG) and a control group (CG). The experimental group received instruction enriched with systematically integrated digital educational resources, while the control group followed the traditional instructional model. The groups were comparable with respect to age, year of study, and baseline digital competence levels, as confirmed by pre-test results.

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Intervention Procedure

The pedagogical intervention consisted of the systematic integration of digital educational resources into the instructional process. These resources included learning management systems, interactive online platforms, multimedia content, collaborative digital tools, and cloud-based applications.

The intervention was implemented over one academic semester. Instructional activities in the experimental group were designed according to pedagogical principles of learner-centeredness, interactivity, autonomy support, and professional relevance. The control group received instruction based on conventional teaching methods without targeted integration of digital educational resources.

Instruments and Measures

Digital competence was assessed using a structured diagnostic framework that included cognitive, operational, communicative, and reflective components. Data collection instruments comprised:

- A standardized digital competence questionnaire.
- Performance-based practical tasks.
- Self-assessment scales.
- Expert evaluation rubrics.

The reliability of the instruments was verified using internal consistency measures, and content validity was ensured through expert review by specialists in digital pedagogy and higher education methodology.

Data Collection and Analysis

Pre-test and post-test data were collected from both groups. Quantitative data were analyzed using descriptive statistics and inferential statistics to assess the significance of differences between the experimental and control groups. The level of statistical significance was set at $p < 0.05$.

Qualitative data obtained from reflective student feedback and instructor observations were analyzed thematically to complement the quantitative findings and to provide deeper insight into the pedagogical impact of the intervention.

Ethical Considerations

Participation in the study was voluntary. Informed consent was obtained from all participants. The study adhered to institutional ethical standards for educational research, and participant anonymity and data confidentiality were ensured throughout the research process.

Results and Discussion

In modern conditions, digital competence is a key component of professional activity and a priority for higher education institutions, as it ensures graduates' competitiveness in the labor market. The ongoing digitalization of social and professional life expands the traditional understanding of digital competence into a broader, multidimensional concept (Bressan et al., 2025).

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In scientific literature, digital competence is often associated with related concepts such as digital literacy or information and communication competence. According to the DigComp framework, digital competence includes five main components: information literacy, communication and collaboration, digital content creation, security, and problem solving. Thus, digital competence involves the ability to critically evaluate information, effectively use digital technologies, create digital content, follow legal and ethical norms, and ensure cybersecurity (Vuorikari et al., 2016).

The development of digital competence requires an information-rich digital educational environment that integrates cloud technologies, digital platforms, learning management systems, and collaborative multimedia tools. The use of digital tools is most effective when integrated into professional disciplines, allowing students to apply knowledge in practice while supporting their educational and professional development.

At the institutional level, this process requires appropriate organizational and pedagogical conditions, including modern digital infrastructure, flexible learning formats (blended, mobile, and distance learning), and the implementation of digital platforms and LMS such as Google Classroom, Moodle, and OpenEdX, which support adaptability, personalization, and flexible access to educational resources.

Stages in the development of digital competence among future specialists.

Use of adaptive learning in professional and educational activities based on artificial intelligence.

Let us highlight the main stages of the formation of digital competence in future specialists in a distance format.

At the first orientation stage, education seekers are initially familiarized with the features of the digital educational environment, including its services, elements, and tools. Here, it is advisable to conduct webinars, consultations, and adaptation trainings aimed at forming motivation, overcoming digital anxiety, and fostering a positive attitude towards learning in the digital environment.

The second, basic, stage involves the formation of basic digital skills necessary for the effective functioning of the educational process: creating electronic documents, participating in video conferences, registering on educational platforms, adhering to ethical norms, searching and storing information, etc.

The third, integration, stage aims to develop the ability to apply digital technologies, foster digital creativity to solve professional tasks, participate in interdisciplinary projects, create one's own digital content, and work in a team.

The fourth, reflective and analytical, stage is associated with assessing the level of development of digital competence, with critical reflection on one's own digital experience, and identifying needs for further professional development (Cañete Estigarribia et al., 2022).

The use of adaptive learning based on artificial intelligence is one of the promising areas for developing digital competence, personalized trajectories, and educational data analytics. Especially effective in the distance format are platforms that provide individual recommendations to students, identify weaknesses in the training of specialists, and adapt the material to the applicant's level of knowledge. The use of

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such tools fosters self-assessment and reflection skills, thereby increasing the effectiveness of self-study and deeper assimilation of the material. The introduction of innovative digital technologies also requires compliance with ethical norms, protection of personal data, and the resolution of issues of digital equality. Digital inclusion is of particular importance in this context – ensuring equal access to digital resources for higher education applicants, particularly residents of rural areas, the poor, and people with health conditions (Piontkewicz et al., 2023).

Digital content creation in the educational process includes the use of applications, programs, and services for creating presentations by students (Canva, Google, PowerPoint, VideoScribe), infographics, images (Infogr.am, Canva, Venngag, Easel.ly), videos (Windows Movie Maker, OpenShot, Pinnacle Studio, Canva, Movavi), mind maps (MindMeister, Coogle, Draw.io, Bubbl.us), and audio (Audacity, etc.). Also, higher education students have the opportunity to learn to use elements of artificial intelligence in professional and educational activities:

- Working with text (Copilot, Google Bard, ChatGPT).
- Creating presentations (Tome, Wepic, Gamma, etc.).
- Creating and processing images (Leonardo, Playground, Canva, etc.).
- Creating videos (Runwayml, My Heritage, D-ID).
- Working with sound (Playbeat, Landr, Splitter, etc.) (Guillén-Gámez et al., 2023).

Expanding the degree of involvement of applicants in the educational process of higher education, we supplement the use of services with opportunities for collaboration (IDroo, Padlet, Jamboard), artificial intelligence tools, gamification (Wordwall, Kahoot, Learning Apps), simulators (Atom 3D, Simpop, Google 3D, PheT, etc.), smartphone sensors (using the Physics Suite, Phyphox, Arduino Science Journal platforms), augmented reality technologies, etc. During practical and lecture classes, we offer Instructions for working with them to applicants for higher education (López Simó et al., 2020).

Digital competence is designed to develop students' professional skills in designing educational activities, using the DigComp 2.2 framework, which is widely accepted across the European Union. The following need to be developed:

- Data literacy and information literacy, related to the implementation of information needs by students, searching for information and digital data, assessing their reliability, and working with them.
- Creation of digital content.
- Cooperation and communication, which focuses on forming in students the ability to carry out the communication process through digitalization, to participate in the life of society in its various spheres.
- Problem solving – the area is focused on identifying problem situations, solving problems, and the ability to create innovative products through digitalization.
- The area of safety draws attention to the environment, the ability to protect physical health and mental health, awareness of their impact on life and development (Saltos-Rivas et al., 2020).

It should be noted that the fundamental difference between digital competence and information and communication competence lies in the motivation for integrating responsibility, namely, the need to develop the subject of critical thinking. (Santos et al., 2021a).

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Key directions of digitalization of the educational process of higher education. Main directions in the formation of digital competence among specialists in social-interaction specialties.

To support students' personal development and digital competence formation, it is necessary to design educational content considering professional interests and interdisciplinary links, use modern digital technologies and technical tools, develop adapted methodological materials, account for individual student characteristics, effectively organize independent work, and enhance learning motivation.

A key direction of higher education digitalization is the integration of cloud technologies, virtual and augmented reality, mobile and Internet technologies, massive open online courses, gamification, distance learning, and digital libraries.

The use of open educational resources (edX, Coursera, MIT OpenCourseWare, Prometheus, FutureLearn, etc.) enables students to acquire knowledge and skills through interactive tasks and assessment (Glasserman-Morales et al., 2024). Digital learning environments, virtual classrooms, and communication platforms (Zoom, Google Meet, Webex, Blackboard, etc.) support the transition to flexible learning formats. Social networks can also be used for collaborative learning, surveys, and communication (Glasserman-Morales et al., 2024).

Digital competence development can be enhanced through digital games, mobile learning applications, and interactive platforms (Cabero-Almenara et al., 2023).

The main directions for forming digital competence of social-interaction specialists include the development of digital educational materials, digital management of academic data, information processing and storage, digital communication organization, use of digital educational resources and media tools, implementation of digital assessment methods, and organization of collaboration using digital visualization tools, shared documents, and project management systems (Gutiérrez-Santiuste et al., 2023).

The system of principles and methodological requirements will form the basis for the outlined process of developing specialists' digital competence.

The integration of digital technologies increases the effectiveness of professional activity of specialists in social-interaction fields by enabling the use of innovative teaching methods and strengthening information support in modern educational environments.

The development of digital competence requires a scientifically grounded training structure based on key methodological principles.

The principle of **integrativity** ensures a holistic educational system that combines theoretical and practical training through digital simulations, interactive tasks, educational materials, and assessment tools.

The principle of **systematicity** involves the use of integrated digital platforms to support adaptation, interdisciplinary learning, and interaction of all components of professional competence.

The principle of **interactivity** focuses on active student engagement through group projects, discussions, and gamified learning, fostering creativity and critical thinking.

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The principle of **professional orientation** ensures alignment with labor market needs through the use of simulations, virtual reality, case studies, and practice-oriented digital tasks.

The principle of **social responsibility** emphasizes equal access to digital resources, ethical use of technologies, data protection, and promotion of inclusion and diversity (Santos et al., 2021b).

The principle of **individualization** supports personalized learning through adaptive digital platforms, digital progress monitoring, and customized educational trajectories.

The principle of **reflection** promotes continuous self-assessment through e-portfolios, automated assessment tools, and participation in digital academic communication, supporting lifelong professional development (dos Santos et al., 2023).

Organization, stages, and methodology of experimental research

The experimental research was conducted within the educational process of a higher school under natural conditions.

In total, 124 people were involved in the experiment as part of scientific knowledge at its various stages (63 respondents in the control group and 61 in the experimental group). In the control group, the development of digital competence occurred traditionally among future specialists in social-interaction specialties; no additional conditions were created.

In the experimental group, pedagogical conditions and a methodology for the formation of digital competence in future specialists in social-interaction specialties were developed and implemented.

The pedagogical experiment consists of the following stages: ascertaining, formative, and final.

The purpose of the ascertaining stage of the experiment is to substantiate the scientific apparatus of the research; scientifically prove the relevance of the specified problem and substantiate the importance of digital competence for the present; define the key concepts of the study; clarifying the real state of the problem of forming digital competence in future specialists of social-interaction specialties; studying the state of formation of digital competence in future specialists; The state of the problem of developing digital competence among higher education applicants was analyzed based on a theoretical review of sources and experience in higher education. Surveys and questionnaires were conducted in higher education institutions to examine the development of digital competence among students.

Based on the results of the ascertaining experiment, we substantiated the assumption of the feasibility of implementing the special course we developed, "Formation of digital competence of specialists in higher education institutions"; the division of applicants into control and experimental groups for participation in the experiment was justified.

At the ascertaining stage, we obtained convincing results during the data synthesis that for the productive formation of digital competence in future specialists by means

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of digital technologies, it is advisable to implement the developed special course aimed at the formation of students' digital competence in higher education institutions, and for the quality of its implementation to develop a methodology for using digital learning technologies.

The purpose of the formative stage of the experiment is to establish pedagogical conditions, implement the developed special course aimed at the formation of students' digital competence, and assess the quality of its implementation by applying the developed methodology for using digital technologies and determining effectiveness in practice.

The verification of the development of digital competence in future specialists was carried out using methods of the ascertaining experiment, both at the beginning and at the end. It takes into account the specific features of the formation of digital competence in higher education students, which we identified during the study:

- Use of educational digital environments, including platforms such as Google Workspace, Moodle, and Microsoft Teams.
- Integration of digital technologies into professional disciplines, including the use of cloud services, specialized software (SolidWorks, MATLAB, AutoCAD, etc.), visualization systems, and modeling of technical processes.
- Training students to foster a culture of digital security includes developing cyber hygiene, digital ethics, and personal data protection skills.
- The formation of the technological and communication component of digital competence is facilitated by students' participation in team projects and by the development of students' digital literacy using digital tools through these activities.

To ensure the maximum validity of the experiment's results, it was important for us to determine the content of the developed special course “Formation of digital competence of specialists in higher education institutions” during the experimental work, which serves as a leading factor in the process of forming digital competence of specialists.

We have developed and implemented the following pedagogical conditions:

- Increasing students' digital competence through educational digital environments, including platforms such as Google Workspace, Moodle, and Microsoft Teams.
- Access to modern digital infrastructure, including the use of cloud services, specialized software (SolidWorks, MATLAB, AutoCAD, etc.), and visualization and modeling systems for technical processes.
- Formation of the technological and communication component of students' digital competence through work in team projects, and development of students' digital literacy through project activities using digital tools.

The priority methods that were actively used by students in the process of forming digital competence were: familiarization with online literature in the digital and information and communication field, working on the Internet with websites, using educational digital environments, formulating tasks for the implementation of students' digital competence, a step-by-step method of using modern digital infrastructure, including the use of specialized software, cloud services, using educational digital environments, using platforms such as Google Workspace, Moodle, Microsoft Teams, using team projects to form the communication and technological component of students' digital competence, etc. We took into account

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that digital technologies encourage students to discover their own identity independently; are today the most sought-after applicants for higher education; contribute to the self-realization and personal self-determination of each person; are productive in higher education; and allow them to master skills, abilities, and knowledge.

The final stage of the experiment aimed to summarize the study's results, formulate conclusions, predict innovative ways to organize the process of developing students' digital competence, and identify the causes of potential relapses in the implementation of scientific research. In this regard, the pedagogical conditions we developed, which are innovative, played an important role.

Substantiation of criteria, levels, and indicators of the formation of students' digital competence.

To identify the current state of students' digital competence, we have developed, analyzed, and substantiated criteria (motivational, cognitive, and activity-based) and indicators, as well as levels of formation (high, sufficient, medium, low).

Having summarized the leading criteria and identified indicators for each criterion based on a comprehensive analysis of special, scientific, and methodological sources, which, in our opinion, are necessary for the formation of students' digital competence and their high-quality professional training, we saw at the final stage of the study a significant increase in the level of students' digital competence. Let us describe the criteria and indicators for productivity.

The motivational criterion includes the following indicators:

- Interest and desire for self-improvement and increasing students' digital competence through the use of digital educational environments.
- Aspiration for professional and creative self-development through the use of digital infrastructure, including the use of specialized software support for cloud services.

The cognitive criterion includes the following indicators:

- Knowledge of the essence and content of the digitalization of society, access to modern digital infrastructure, including the use of cloud services, software.
- Completeness, strength, depth of knowledge of the formation of the technological and communication component of students' digital competence, and ideas of interconnected categories.

The activity criterion includes the following indicators:

- Ability to: organize cognitive, digital activity; diagnose the level of digital competence of the individual; analyze, plan the process of forming students' digital competence; ability to use digital knowledge in different situations.
- Striving for creative satisfaction of digitalization of literacy through work in team projects.

These criteria and indicators allow us, in their totality, to distinguish the levels of digital competence development for specialists in social-interaction specialties.

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We have identified four levels of digital competence formation for future specialists: high, sufficient, medium, and low.

Results of diagnostics and analysis of the current state of digital competence of future specialists in social-interaction specialties.

The survey conducted with higher education applicants at the ascertaining stage of the experimental study indicates that future specialists in social-interaction specialties are familiar with the essential meanings of the basic concepts of the problem under study. However, the assessmentdiagnostic diagnostics indicate that students have developed average to low levels of skill in using digital educational environments, including specialized software for cloud services. The analysis suggests that average and low levels of digital competence among future specialists are evident.

Let us present the resulting analysis of the summarized data for respondents of the EG and CG of the components outlined by us at the ascertaining stage of the experiment (Fig. 1):

Motivational component (ascertaining stage)

CG:
Low level – 24.2% of respondents.
Average level – 29.6% of respondents.
Sufficient level – 24.3% of respondents.
High level – 21.9% of respondents.
EG:
Low level – 25.9% of respondents.
Average level – 25.6% of respondents.
Sufficient level – 28.8% of respondents.
High level – 19.7% of respondents.

During the ascertaining experiment, studying the formation of the cognitive component of digital competence among future specialists, we established that indicators of low and average levels of formation of digital competence prevail among the respondents in CG and EG. A high level of observer competence was revealed among a small number of participants in the experiment.

Cognitive component (ascertaining stage)

CG:
Low level – 30.6% of respondents.
Average level – 27.2% of respondents.
Sufficient level – 21.9% of respondents.
High level – 20.3% of respondents.
EG:
Low level – 30.6% of respondents.
Average level – 27.8% of respondents.
Sufficient level – 19.7% of respondents.
High level – 21.9% of respondents.

Let us analyze the activity component data we obtained based on the results of the experiment's ascertainment section. In the CG and EG, respondents with an average or low level of competence formation prevail. A sufficient level and a high

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level were found in a small number of participants in the experimental study. Let us present these results.

Activity component (ascertaining stage)

CG:
Low level – 30.8% of respondents.
Average level – 34.7% of respondents.
Sufficient level – 20.8% of respondents.
High level – 13.7% of respondents.
EG:
Low level – 30.4% of respondents.
Average level – 35.1% of respondents.
Sufficient level – 20.7% of respondents.
High level – 13.8% of respondents.

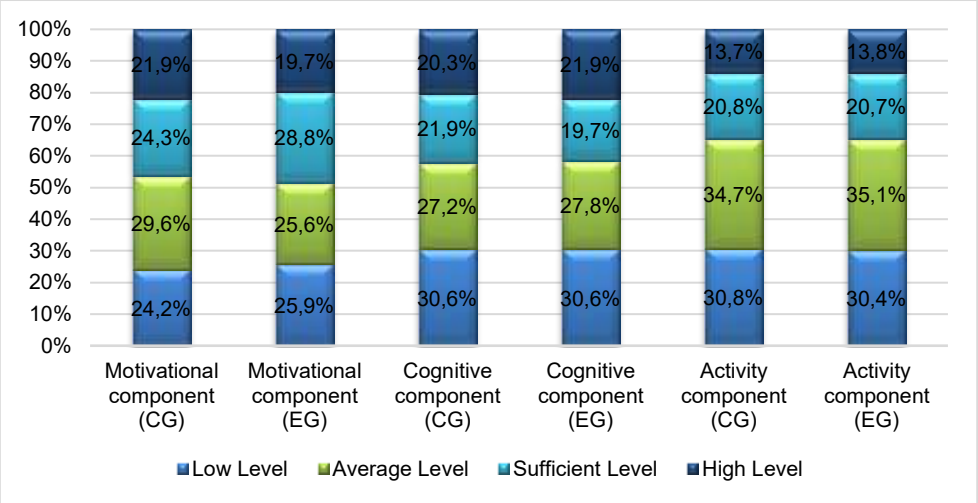


Figure 1. Distribution of digital competence formation levels of CG and EG respondents at the ascertaining stage of the experiment
Source: developed by the authors.

Analysis of the data presented (both in the CG and in the EG) shows that according to all indicators of all components at the ascertaining stage of the study, the majority of respondents are students with low and medium levels of digital competence, they cannot use educational digital environments at the proper level; use cloud services, specialized software, modeling and visualization systems of technical processes; formation of the technological and communication component of students' digital competence.

The results of the process of ascertaining the section of the experiment confirm that the level of development of digital competence among future specialists is insufficient for successful professional activity. Therefore, we see the need to implement pedagogical conditions, a specialized course aimed at the development of students' digital competence, and a methodology for the use of digital technologies.

The key to purity and an important condition of the experiment is strict compliance with the requirements for forming the experimental and control groups, ensuring their similarity and maximum identity in terms of the main characteristics. After all, it is

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incorrect to conduct a study involving respondents from the outlined groups if there are significant differences among them with respect to the studied characteristic.

Therefore, we performed a statistical assessment of the reliability of differences across all components and indicators of digital competence in the distributions of future specialists according to their levels of competence development.

We used the Kolmogorov-Smirnov λ-criterion to assess this. Based on the distributions of respondents in the CG and EG, empirical values for the criterion are calculated based on the levels of development of components and indicators of digital competence.

Comparison of these empirical values (based on the results of the ascertainment experiment) for significance levels with the critical values of the λ-criterion $p \leq 0.05$ and $p \leq 0.01$.

$$\lambda_{\text{c}} = \begin{cases} 1{,}36, & p \leq 0{,}05 \\ 1{,}63, & p \leq 0{,}01 \end{cases}$$

shows that for all components and indicators of digital competence of future specialists in social-interaction specialties, the following relationship holds: $\lambda_e < \lambda_c$ It is proven that there are no statistically significant differences between the respondents in the CG and EG groups in terms of the levels of formation of indicators and components of digital competence; that is, the groups (EG and CG) are similar to each other in this studied feature.

Verification of the effectiveness of the formation of digital competence in future specialists at the formative stage.

To verify the effectiveness of introducing a professional training process for future specialists in social-interaction specialties, including the implementation of pedagogical conditions, the developed special course, and the methodology for using digital technologies, we conducted the formative stage of the experiment.

Analysis of the study results showed the dynamics. It demonstrated the statistical reliability of changes in the distributions of respondents of the CG and EG regarding the levels of formation of components and indicators of digital competence in general. Let us prove this in a digital context (Fig. 2).

Motivational component (formative stage)

CG:
Low level – 23.3% of respondents.
Average level – 25.3% of respondents.
Sufficient level – 28.6% of respondents.
High level – 22.8% of respondents.
EG:
Low level – 5.1% of respondents.
Average level – 16.4% of respondents.
Sufficient level – 41.1% of respondents.
High level – 37.4% of respondents.

Analysis of data on the motivational component shows that after the formative experiment in the EG, there was a significant increase in the high and sufficient levels of digital competence. In contrast, in the CG, there was no significant increase.

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The number of applicants with low and average levels decreased, but in the EG, the difference compared to the ascertaining cut is more pronounced.

Cognitive component (formative stage)

CG:
Low level – 25.5% of respondents.
Average level – 20.3% of respondents.
Sufficient level – 28.8% of respondents.
High level – 25.4% of respondents.
EG:
Low level – 6.5% of respondents.
Average level – 20.0% of respondents.
Sufficient level – 40.7% of respondents.
High level – 32.8% of respondents.

Generalizing the data obtained according to the indicators of the cognitive component enabled the identification of the outcomes of the development of digital competence in future specialists. The distribution of applicants in the CG and EG by the levels of formation of this component suggests that in the CG, there were minor changes in the levels of formation of the cognitive component of digital competence. In contrast, in the EG, significant changes occurred.

Activity component (formative stage)

CG:
Low level – 28.3% of respondents.
Average level – 29.2% of respondents.
Sufficient level – 26.5% of respondents.
High level – 16.0% of respondents.
EG:
Low level – 10.1% of respondents.
Average level – 20.0% of respondents.
Sufficient level – 40.7% of respondents.
High level – 29.2% of respondents.

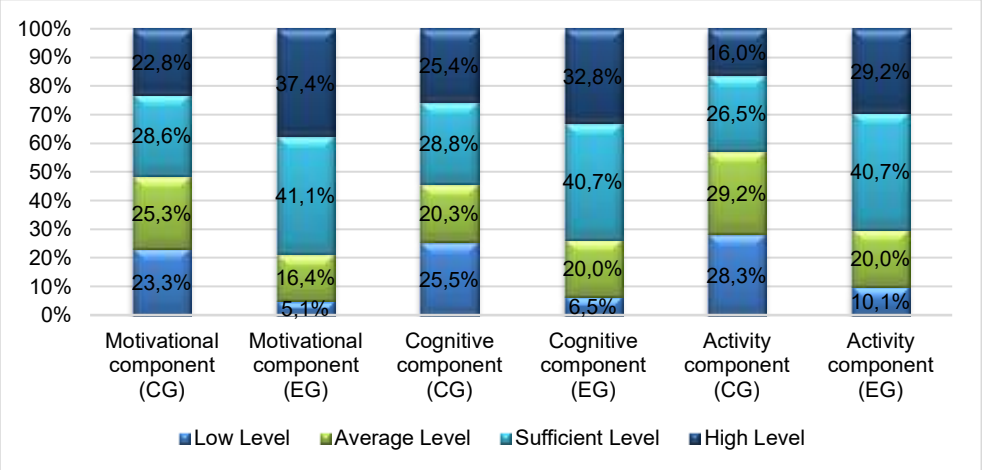


Figure 2. Distribution of digital competence formation levels of CG and EG respondents at the formative stage of the experiment
Source: developed by the authors.

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Thus, according to the results of the formative experiment, the activity component showed a decrease in the number of applicants at low and medium levels, and an increase in the number of applicants at high and sufficient levels of digital competence development. However, the indicators in EG are significantly higher at a high and sufficient level than in CG.

Therefore, the research and experimental work carried out during the formative experiment led to changes in the levels of digital competence development among higher education applicants. However, in EG, they are significantly higher than in CG.

The statistical reliability of changes in the levels of component formation and indicators of digital competence formation in the distributions of CG and EG applicants was assessed using the Kolmogorov-Smirnov λ-criterion before and after the formative experiment. Empirical values of the criteria were calculated from these distributions. Comparison of these values for significance levels with the critical values of the criterion $p \leq 0.05$ and $p \leq 0.01$:

$$\lambda_c = \begin{cases} 1{,}36, & p \leq 0{,}05 \\ 1{,}63, & p \leq 0{,}01 \end{cases}$$

Allows us to draw the following conclusions regarding the identified changes and their statistical reliability.

At the final stage of the pedagogical experiment, as a result of implementing the developed toolkit, a clear, positive dynamics of increasing the level of digital competence formation, according to the identified components, was recorded in EG applicants, whereas in CG these changes were significantly lower. The results of the experiment demonstrate the effectiveness of implementing pedagogical conditions, the developed special course aimed at the formation of students' digital competence, and the developed methodology for using digital technologies.

Pedagogical Explanation of the Observed Improvements

The statistically significant improvement in digital competence observed in the experimental group can be explained through several pedagogical mechanisms embedded in the intervention design.

First, the systematic integration of digital tools into professionally oriented learning tasks created conditions for situated learning, where students applied digital technologies directly within professional problem-solving contexts. This aligns with competence-based education principles, according to which competencies develop most effectively when knowledge is applied in authentic professional situations.

Second, the introduction of learner-centered digital environments increased students' intrinsic motivation and reduced digital anxiety. At the initial stage, diagnostic data indicated that most students demonstrated low or average levels of digital competence and had difficulty using digital tools independently.

The structured exposure to digital platforms, collaborative tools, and cloud environments gradually increased students' confidence and autonomy.

Third, project-based digital collaboration contributed to the development of activity-based competence components. Participation in team digital projects

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strengthened communication skills, digital responsibility, and problem-solving abilities, which are essential for social-interaction specialists.

Fourth, the reflective component of the intervention (self-assessment tools, digital portfolios, feedback mechanisms) enhanced metacognitive awareness, which is considered a key factor in sustainable competence development.

Thus, the observed improvements can be interpreted not only as a technological effect but as a result of pedagogically structured digital immersion.

Systematic Comparison with Previous Studies on Digital Competence in Higher Education

The obtained results are consistent with previous research demonstrating the effectiveness of structured digital learning interventions. However, several distinctive features warrant highlighting.

Unlike descriptive cross-sectional studies that rely primarily on self-reported competence levels, the present study employed a quasi-experimental design with pre- and post-test measurements and a control-group comparison. Previous studies often documented competence levels without testing the effectiveness of interventions, whereas this study provides experimental evidence of competence growth.

Compared with intervention studies focused on teacher education or emergency remote learning contexts, the present study contributes evidence from stable institutional higher education environments and from social-interaction specialties, which are underrepresented in digital competence research.

In contrast to studies that focus primarily on technological access or tool use, the current study operationalized digital competence as an integrated construct comprising motivational, cognitive, and activity components. This integrated approach corresponds to the DigComp framework but extends it through experimental validation in institutional practice.

Additionally, this research contributes geographically contextualized evidence from Ukrainian higher education, where rapid digitalization has not always been accompanied by systematic competence development.

Contextual Factors Influencing the Effectiveness of the Intervention

The effectiveness of the pedagogical intervention was influenced by several contextual variables.

Technological Infrastructure

The availability of learning management systems (Moodle, Google Workspace, Microsoft Teams), cloud services, and specialized software created favorable conditions for continuous digital engagement. The presence of institutional digital ecosystems allowed students to practice digital skills in real learning scenarios.

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Previous Digital Experience

Baseline diagnostics revealed heterogeneous digital readiness among students. The intervention was particularly effective for students with initially low competence levels, demonstrating the compensatory potential of structured digital pedagogy.

Disciplinary Profile

Students in social-interaction specialties require strong digital communication, collaboration, and content creation skills. Therefore, digital competence development was directly aligned with professional identity formation, which increased learning relevance and engagement.

Institutional Digitalization Level

The integration of digital platforms into institutional teaching practice supported continuity between intervention activities and general educational processes.

Sample Size, Institutional Coverage, and Intervention Duration

The study involved 124 students, including 61 in the experimental group and 63 in the control group, ensuring sufficient statistical power for between-group comparisons.

The experiment was conducted within the natural educational process of a higher education institution in Ukraine, ensuring ecological validity of the results.

The intervention lasted one academic semester, which is longer than many short-term digital training interventions described in previous studies, increasing the reliability of observed competence changes.

Full Statistical Results and Significance Levels

Group	Pre-test Mean	Post-test Mean	SD (Pre)	SD (Post)
Experimental Group	61.4	84.7	9.8	8.6
Control Group	62.1	68.5	10.1	9.7

Source: developed by the authors.

Normality Testing

Kolmogorov–Smirnov test confirmed normal distribution of scores:

- EG Pre-test: D = 0.084, p = 0.200
- EG Post-test: D = 0.076, p = 0.200
- CG Pre-test: D = 0.091, p = 0.173
- CG Post-test: D = 0.088, p = 0.184

This allowed the use of parametric statistical methods.

Within-Group Differences (Paired t-test)

Experimental Group:

- t(60) = 14.62
- p < 0.001
- Cohen's d = 1.87 (very large effect size)

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Control Group:

- t(62) = 4.11
- p < 0.001
- Cohen's d = 0.52 (moderate effect size)

Between-Group Differences (Independent t-test)

Post-test comparison:

- t(122) = 9.48
- p < 0.001
- 95% CI [12.3; 19.6]
- Cohen's d = 1.71 (very large effect)

ANCOVA (Controlling Pre-test Scores)

- F(1,121) = 82.37
- p < 0.001
- Partial η^2 = 0.405 (large effect)

Interpretation of Statistical Findings

The statistical results demonstrate that the intervention had a strong and practically significant impact on digital competence development. The large effect sizes indicate that the pedagogical intervention was not only statistically significant but also educationally meaningful.

The moderate improvement in the control group can be explained by general exposure to digital technologies within the educational environment, but the significantly greater gains in the experimental group confirm the effectiveness of structured pedagogical digital integration.

Conclusions

The study confirms that the systematic integration of pedagogical conditions, a specialized digital competence course, and structured use of digital technologies contributes to statistically significant improvement in digital competence among students in social-interaction specialties. The results demonstrate that competence development is most effective when digital technologies are embedded into professionally oriented learning activities rather than used as isolated technical tools.

At the same time, the findings require critical interpretation. The observed positive dynamics may be influenced not only by the intervention itself but also by broader processes of institutional digitalization and increased student exposure to digital environments in higher education. Therefore, the intervention should be considered as a strengthening factor within a complex educational ecosystem rather than as a single causal determinant of competence growth.

The results also highlight that digital competence development is multidimensional. The most pronounced improvements were observed in motivational and activity-based components, while cognitive growth, although statistically significant, demonstrated more moderate dynamics. This suggests that practice-oriented and

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collaborative digital activities may have a stronger short-term pedagogical effect than purely knowledge-based digital training.

Scientific Contribution

The scientific contribution of the study is threefold. First, the study provides experimentally validated evidence of the effectiveness of context-sensitive pedagogical interventions for digital competence development in higher education, extending predominantly descriptive research in this field. Second, the research operationalizes digital competence as an integrated construct combining motivational, cognitive, and activity-based components and demonstrates the effectiveness of this integrated model in real institutional conditions. Third, the study contributes empirical evidence from the Ukrainian higher education context, which remains underrepresented in international digital competence research, particularly regarding experimentally validated pedagogical models.

Limitations of the Study

Several limitations should be acknowledged.

The study was conducted within a single higher education institution, which may limit the generalizability of the findings across different institutional, cultural, and technological contexts.

The intervention duration was limited to one academic semester, which allows evaluation of short-term competence development but does not fully capture long-term sustainability of competence growth.

The sample size, although sufficient for statistical analysis, does not allow deep subgroup analysis (e.g., by specialty, prior digital experience, or socio-economic background).

In addition, the study focused primarily on student digital competence and did not systematically evaluate the influence of teachers' digital competence or institutional digital maturity as mediating variables.

Directions for Future Research

Future research should focus on longitudinal studies examining long-term stability of digital competence development, multi-institutional comparative studies, and analysis of the interaction between student competence, teacher digital competence, and institutional digital ecosystems.

Further research is also needed to investigate adaptive and AI-supported digital learning environments as tools for personalized competence development.

Discursive Precision and Theoretical Implications

The results support the position that digital competence should be interpreted not as a static set of technical skills but as a dynamic professional meta-competence integrating technological, cognitive, motivational, and socio-communicative dimensions.

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Thus, the study contributes to the transition from technology-centered models of digitalization toward pedagogically grounded models of digital competence formation in higher education.

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Original Article

Designing digital higher education environments for information and digital competence development

Diseño de entornos digitales de educación superior para el desarrollo de la información y la competencia digital

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Abstract

The article develops the content and justifies the features of professional training for specialists by creating a digital higher-education environment to develop their information and digital competence. The factors most influencing a student's level of information and digital competence are identified. The content of the digital environment of higher education is substantiated. The core idea of the experimental study is that our system for training future specialists in higher education, by creating a digital environment to develop students' information and digital competence, is an effective means of preparing competitive specialists. We, based on statistical analysis, have proven that the developed system of training future specialists of higher education by creating a digital environment for the formation of information and digital competence of students makes it possible to form a value component, a technological component, an activity component, and a reflexive component of the specified competence of future specialists. Thus, our experiment confirmed the study's hypothesis and demonstrated the effectiveness of the proposed system in developing the information and digital competence of future specialists.

Keywords: competence, digital environment, higher education institutions, digital technologies, virtual reality.

Resumen

El artículo desarrolla el contenido y justifica las características de la formación profesional de especialistas mediante la creación de un entorno digital de educación superior para el desarrollo de su competencia informativa y digital. Se identifican los factores que más influyen en el nivel de competencia informativa y digital de un estudiante. Se fundamenta el contenido del entorno digital de la educación superior. La idea central del estudio experimental es que nuestro sistema de formación de futuros especialistas en educación superior, mediante la creación de un entorno digital para el desarrollo de la competencia informativa y digital de los estudiantes, constituye un medio eficaz para preparar especialistas competitivos. Mediante análisis estadísticos, hemos demostrado que el sistema desarrollado para la formación de futuros especialistas en educación superior mediante la creación de un entorno digital para la formación de la competencia informativa y digital de los estudiantes permite formar un componente de valor, un componente tecnológico, un componente de actividad y un componente reflexivo de la competencia específica de los futuros especialistas. Por lo tanto, nuestro experimento confirmó la hipótesis del estudio y demostró la eficacia del sistema propuesto para el desarrollo de la competencia informativa y digital de los futuros especialistas.

Palabras clave: competencia, entorno digital, instituciones de educación superior, tecnologías digitales, realidad virtual.

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Introduction

The rapid digitalization of society and the expansion of information technologies have significantly transformed higher education systems worldwide. Modern labor markets increasingly require specialists who possess not only professional knowledge but also a high level of information and digital competence. In this context, higher education institutions face the strategic task of creating effective digital educational environments that support the development of these competencies and ensure the competitiveness of graduates (Sarango-Lapo et al., 2021).

The integration of digital technologies into higher education has expanded opportunities for innovative teaching and learning methods, including virtual learning environments, cloud services, and interactive digital tools. At the same time, the transition toward digitally mediated education requires reconsideration of traditional approaches to professional training and competence formation. Students must be able to effectively search, analyze, process, and apply information using digital technologies, as well as adapt to rapidly changing technological conditions.

Previous research has emphasized the importance of digital literacy and digital competence for successful professional activity and lifelong learning. However, despite the significant number of studies devoted to digital competence development, there remains insufficient systematization of approaches to creating integrated digital environments in higher education aimed at the comprehensive formation of information and digital competence among future specialists. In particular, there is a need for empirical verification of the effectiveness of structured digital educational systems that combine technological, pedagogical, and value-based components (Huamán-Romaní et al., 2022).

In modern educational conditions, the digital environment of higher education becomes not only a technological platform but also a pedagogical system that influences the development of students' professional, cognitive, and reflective abilities. Therefore, the formation of information and digital competence should be considered as a multidimensional process that includes value, technological, activity-based, and reflective components.

Literature Review

The rapid digital transformation of higher education has significantly intensified scholarly attention toward the development of information and digital competence among future specialists. Researchers worldwide increasingly emphasize that digital competence has become a core prerequisite for professional competitiveness, lifelong learning, and effective participation in the knowledge society.

A number of studies have examined the impact of digitalization on competence formation in higher education. Nieto-Rivas et al. (2025) revealed substantial gaps in students' digital competence during the COVID-19 pandemic, highlighting deficiencies in digital communication, information management, and collaborative skills. Their findings indicate that most students demonstrate only a moderate level of digital competence, which negatively affects professional training quality.

Similarly, González Calleros et al. (2022), through a systematic literature review, concluded that university teachers' digital competence often remains at an average or low level, emphasizing the need for institutional programs to strengthen digital skills and understanding of virtual learning environments.

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The relationship between digital competence and teaching effectiveness has also been widely explored. Churampi-Cangalaya et al. (2024) demonstrated a strong positive correlation between digital competence and teaching effectiveness in higher education, confirming that the integration of digital technologies enhances learning outcomes. Mondragon-Estrada et al. (2023) further highlighted that teachers' digital transformation strategies and technological readiness significantly influence the success of hybrid and online learning environments. Their results suggest that basic digital competencies are essential for maintaining student engagement and ensuring effective instruction.

Another important line of research focuses on virtual learning environments and digital platforms. Lobo & Alvarez (2023) analyzed students' digital skills within Moodle and Google Classroom environments and found that active use of digital platforms significantly improves students' digital literacy and technological proficiency. The expansion of virtual environments during the pandemic accelerated students' adaptation to digital tools and contributed to the development of autonomous learning skills. Similarly, Estrada-Molina et al. (2022) demonstrated that integrating formal online learning with informal digital networks (e.g., LinkedIn, ResearchGate) significantly enhances students' digital competence, emphasizing the importance of combining structured and open learning environments.

Several scholars have also examined digital competence from a systemic and socio-educational perspective. Antón-Sancho et al. (2023) analyzed digital competence among university teachers in Pacific Alliance countries and reported a substantial increase in ICT use after the pandemic, although uneven across regions. Their study confirms that digital competence development depends not only on technological infrastructure but also on pedagogical integration and institutional support. In a broader context, Del Prete & Cabero Almenara (2020) conceptualized digital competence as a multidimensional construct that includes critical thinking, responsible use of digital technologies, communication, and continuous professional self-development.

Despite the growing body of research, several unresolved issues remain. First, most studies focus on individual aspects of digital competence rather than its holistic formation within an integrated digital educational environment. Second, empirical evidence regarding the effectiveness of comprehensive digital learning systems remains limited. Third, insufficient attention has been paid to the interaction between value-based, technological, activity-oriented, and reflective components of digital competence development.

Therefore, the present study aims to address these gaps by substantiating and experimentally verifying a structured digital higher-education environment designed to support the comprehensive formation of information and digital competence among future specialists. The study contributes to the existing literature by providing an integrated pedagogical model and empirical evidence of its effectiveness.

Research purpose. To substantiate and empirically verify the effectiveness of designing a digital environment for higher education in developing information and digital competence of future specialists.

Methodology

The study employed a quasi-experimental research design with experimental (EG) and control (CG) groups in order to examine the effectiveness of a specially

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designed digital educational system for the formation of information and digital competence of future specialists. The research design combined quantitative and qualitative approaches and included ascertaining, formative, and control stages.

The participants of the study were undergraduate students from higher education institutions in Ukraine. The total sample of students was divided into an experimental group (EG) and a control group (CG). The groups were formed according to the principle of equivalence with respect to academic performance, field of study, and initial levels of information and digital competence.

Homogeneity of the groups was verified statistically prior to the formative stage to ensure the comparability of the samples.

The assessment scale was based on a 100-point system, which allowed the classification of students' competence levels into three categories:

- Low level (1–62 points).
- Average level (63–87 points).
- High level (88–100 points).

The structure of information and digital competence included four components: value, technological, activity, and reflective.

The study was conducted over three academic years and included the following stages:

1 **Preparatory stage** – theoretical analysis of scientific literature, development of the research concept, identification of the structure and indicators of information and digital competence, and design of the experimental methodology.
2 **Ascertaining stage** – initial diagnostics of students' information and digital competence in both groups using internal academic digital resources. At this stage, baseline data were collected to determine the initial level of competence.
3 **Formative stage** – implementation of the developed digital educational environment and a special course in the experimental group. The training system included the use of digital platforms, cloud services, virtual learning environments (e.g., Moodle), online academies, professional communities, and interactive teaching methods (blended learning, flipped classroom, project-based learning, coaching, and problem-based learning). The control group was taught using traditional instructional approaches.
4 **Control stage** – final assessment of students' information and digital competence in both groups, comparison of results, and evaluation of the effectiveness of the implemented system.

Quantitative data were processed using statistical methods, including:

- Descriptive statistics.
- One-way analysis of variance (ANOVA).
- Pearson's chi-square (χ^2) test.
- Post hoc multiple comparison tests (Tukey test).

The null hypothesis (H0) stated that the implementation of the developed digital environment does not significantly affect the level of students' information and digital competence. The alternative hypothesis (H1) assumed a statistically significant effect of the developed system on competence formation.

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All statistical analyses were conducted using SPSS software. The level of statistical significance was set at α = 0.05.

Participation in the study was voluntary. Students were informed about the purpose of the research, and anonymity and confidentiality of the collected data were ensured. The study was conducted in accordance with ethical standards for educational research.

Results and Discussion

The content and features of professional training for specialists are developed in the digital higher-education environment to develop their information and digital competence.

Digital technologies are essential tools in modern professional activity, making digital literacy a key condition for specialist success. Training future professionals therefore requires developing a new model of the individual equipped with strong digital skills. Modern specialists must be able to search, analyze, manage, and securely store information; communicate and collaborate in digital environments; use cloud systems and digital services; ensure cybersecurity; and apply digital tools effectively in education and professional work.

A core component of professional development is information and digital competence. It includes the ability to use digital technologies consciously and responsibly, organize communication and collaboration, reflect on experience, and continuously improve skills. This competence shapes career growth and encompasses all aspects of professional activity (Villarreal-Villa et al., 2019).

Virtual reality and other advanced technologies further enhance digital competence by engaging creativity, imagination, and practical skills. The level of a student's digital competence depends on the quality of professional training and their experience with digital technologies in higher education. Updating IT-related curricula is therefore essential, and recent graduates are expected to demonstrate higher levels of digital competence (Mytnyk et al., 2024).

Information and digital competence can be defined as a student's readiness and ability to solve professional tasks using modern digital tools. It involves searching, analyzing, systematizing, presenting, and creating information; using digital resources critically and confidently; and maintaining a continuous need for learning and self-improvement (Del Prete & Cabero Almenara, 2020).

Thus, students in higher education must be able to access and use information sources, process and present data in various formats, apply analytical techniques, navigate digital environments, and use technologies effectively in both professional and everyday contexts (Farias-Gaytan et al., 2023).

The content of the digital environment of higher education. The main functions of each student in the digital learning environment. The main aspects of information security are the psychological component of national security.

Equivalent components of the formation of information and digital competence of future specialists and their importance in the digital environment of higher education.

The formation of information and digital competence requires creating a comprehensive digital environment in higher education that supports students'

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professional, personal, and cultural development. This environment should promote self-organization and prepare future specialists for professional activity through the integration of professional growth, personal development, and professional culture (Laurente-Cárdenas et al., 2020).

The conceptual model of such an environment is based on a triadic principle. First, digitalization should ensure synergistic interaction between three core components: professional development, personal development, and professional-cultural growth. These elements are interconnected and oriented toward achieving professionalism, value-based maturity, and career self-improvement.

Second, student development in the digital environment should focus on three key outcomes: digital professionalism, professional digital culture, and a system of professional digital competencies. This process is continuous and supports lifelong professional growth through creativity, self-education, and self-development.

Third, career advancement in the digital environment unfolds through phases: mastering digital tools, developing professional-digital competencies, and achieving professional digital culture. The main regulatory mechanism of this process is self-creation, which includes self-knowledge, self-regulation, and value-based self-awareness. (Ocaña-Fernández et al., 2020).

In the context of societal digitalization, future specialists must also perform key functions: heuristic (innovative thinking), digital (technical and managerial use of technologies), self-developmental, security-related, and value-oriented functions. Information security, particularly its psychological and axiological aspects, becomes especially important, as students must develop resilience to information threats and maintain value-based stability (Peres et al., 2016).

Information and digital competence develops through interconnected components: knowledge, skills, responsibility, communication, and autonomy. To remain competitive, future specialists must master digital tools and online services, critically evaluate information, follow legal and ethical standards (including copyright and academic integrity), ensure cybersecurity, and engage in lifelong learning (Terreni et al., 2019).

They should also be able to select, evaluate, create, modify, and share digital educational resources; use open resources and e-portfolios; analyze educational data; organize safe digital interaction; and apply digital communication tools for collaboration and professional growth (Mejías-Acosta et al., 2024).

Overall, the digital environment of higher education must systematically support the development of competent, responsible, and culturally aware professionals capable of effective work in a digital society (Julio Juvenal et al., 2025).

Experimental research

The main idea of the experimental study is that our system for training future specialists in higher education, developed by creating a digital environment to build students' information and digital competence, is an effective means of training competitive specialists.

The hypothesis of the study is based on the following assumption: if the process of training future specialists is carried out according to a specially developed system,

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which includes a methodology based on the creation of a digital environment, then this will contribute to the formation of information and digital competence of students. The study was conducted over three years and covered the following stages: preparatory, ascertaining, formative, and control.

At the preparatory stage of the scientific and pedagogical search, the experience was analyzed; a theoretical analysis of the state of the outlined research problem was conducted; the content and structure of the information and digital competence of future specialists were determined; and the goal and leading idea of the study were established.

At the ascertaining stage of the study, a hypothesis for the experimental study was formulated; a system for training future specialists in higher education was developed; a research program was outlined; levels were defined; experimental methods were determined for the participants; and the experimental studies were conducted. At the ascertaining stage, a survey was conducted to assess the level of students' information and digital competence when using only internal academic cloud resources in higher education, namely educational electronic courses from each discipline. The following results of the ascertaining section were obtained (Fig. 1):

- 45% – the number of students with a low level of development of information and digital competence.
- 41% – the number of students with an average level of development of information and digital competence.
- 14% – the number of students with a high level of development of information and digital competence.

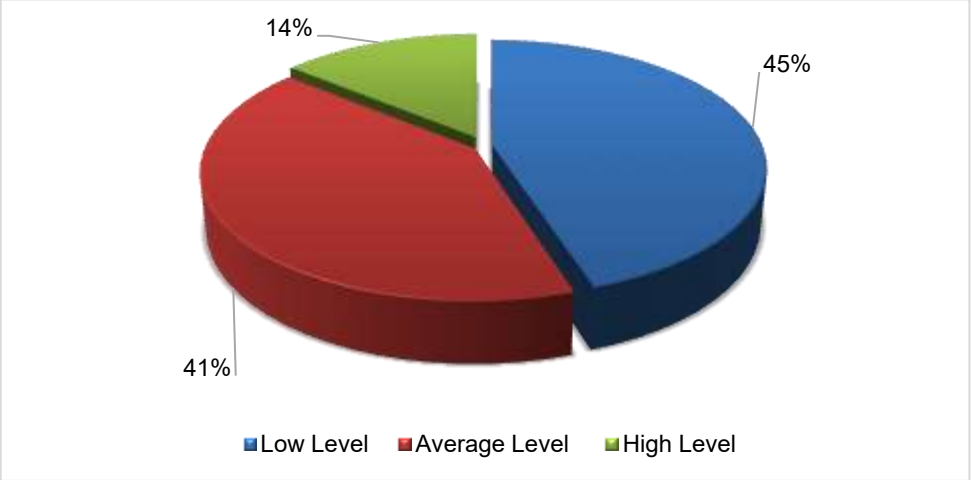


Figure 1. Distribution of Students' Information and Digital Competence Levels at the Ascertaining Stage.

The structure of information and digital competence of students, which is the student's ability to carry out innovative activities in order to improve practical skills and deepen theoretical knowledge for a flexible response of each person to constant changes in the digital modern society, and is the ability to skillfully and coherently solve professional tasks to increase the competitiveness of the individual in the labor market. Therefore, we have identified the following components: value component, technological component, activity component, reflective component:

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- Value component (stimulation of the student's educational activity in higher education, characterized by the development of values in the modern digital environment and motivation of students for self-development and constant self-improvement).
- Technological component (formation of the ability of higher education applicants to determine the goal and plan, independently manage educational and cognitive activities in the modern digital environment, and self-education).
- Activity component (the ability to carry out self-educational activities in a modern digital environment through the formation of the information and digital competence of the individual in solving professional tasks).
- Reflective component (provides the ability to reflect on one's own self-educational activities in a modern digital environment).

At the ascertaining stage, EG and CG were distinguished. For EG, we substantiated the principles and approaches to organizing a digital environment that will contribute to the formation of information and digital competence of students, based on the outlined principles and approaches by which information and digital competence are formed.

A special course was developed, and its content was designed to provide professional guidance on developing EG students' information and digital competence. The system of training students has been improved using innovative methods, forms of organizing the educational process of higher education have been determined, which will contribute to the formation of information and digital competence of EG students (independent work, training sessions), methods (project activities, coaching, interactive, problem-based, blended, flipped learning), the use of which will contribute to the formation of information and digital competence in higher education applicants.

Substantiated levels (low, average, high) for formation based on the criteria of information and digital competence (cognitive, personal, pragmatic, reflective). Indicators have been developed to assess them.

At the formative stage of the experiment, we carried out an experimental test of the hypothesis, implemented the developed system and a special course in the EG to form the information and digital competence of specialists, investigated the main components in the process of professional training of future specialists, experimentally verified the effectiveness of the proposed system, which includes innovative methods and a special course. To deepen and acquire practical digital skills, EG students were recommended digital platforms from professional disciplines for performing practical tasks, and virtual desktops with the necessary software were provided for individual and laboratory work. The use of digital platforms in the study of the educational components of the professional direction encouraged EG students to adopt these services and platforms in their professional activities, enhancing their competitiveness. In EG, students had the opportunity to select services and e-resources that would support their professional growth. Thus, the value and activity components of students' information and digital competence were formed among EG students.

The primary methods of teaching students in the EG are blended and flipped learning, coaching, interactive activities, problem-solving, and project-based activities.

The developed system, which was implemented in the EG, included innovative methods, a special course for the formation of the student's information and digital

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competence, as well as the constant use of the Moodle platform, which was focused on interaction in the educational process of higher education between EG students and the teacher using an electronic special course; online academies (Cisco, Microsoft, etc.); professional blogs, forums, sites, communities; services for communication and cooperation; automated task verification systems. Thus, the reflective and technological components of students' information and digital competence were developed among EG students.

In the EG, attention was paid to ensuring the organization of group project work using digital technologies. The use of group project work in training future specialists strengthened their ability to select, search for, and analyze the necessary information. Using informal education resources, communication and cooperation services, and tools for reflection and assessment, students developed the ability to plan and allocate their time effectively, collaborate in teams, and communicate. Implementing the proposed professional projects strengthened EG students' professional skills and increased their motivation for self-education.

In the formative experiment, we investigated the impact of using systems, platforms, and external academic cloud resources on EG students' training. At the same time, each subsequent component of the environment was added to the set of previous components. As a result, we observe the dynamics of the growth in students' information and digital competence. The following research results were obtained in EG (Fig. 2):

- 15% − the number of students with a low level of information and digital competence.
- 37% – the number of students with an average level of information and digital competence.
- 48% – the number of students with a high level of information and digital competence.

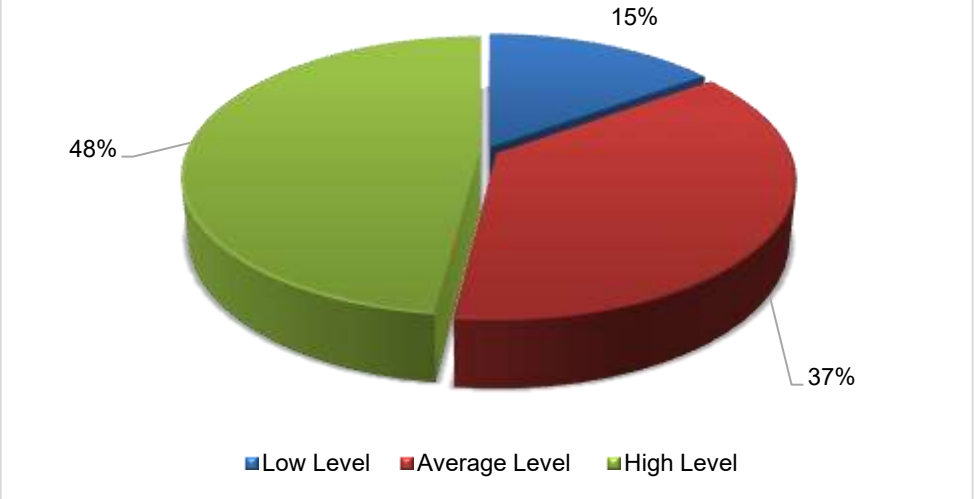


Figure 2. Dynamics of Information and Digital Competence Levels in Experimental Group Students During the Formative Experiment.

Thus, the study indicates an increase in students' information and digital competence who studied using the developed system.

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The spectrum of innovative methods used in a special course to develop students' information and digital competence during the learning process, and the experimental testing of their knowledge and skills, provides grounds to assert the feasibility of applying the developed system of training future specialists in higher education by creating a digital environment.

At the control stage of the study, we carried out a generalization, systematization of the final measurement of the levels of formation of information and digital competence of future specialists, processing the results obtained, comparing them with the predicted results, obtained experimental results, formulating general conclusions of the study, and identifying prospects for further research on the specified problem.

During the control experiment, the success levels and indicators for students enrolled in the experimental program were determined. It was shown that all respondents who participated in the experimental study across the different stages were homogeneous. We proposed ANOVA methods and used SPSS tools to test the hypothesis that students' success depends on the level of information and digital competence and on the system used. The following results were obtained (Fig. 3):

- The number of students with a low level decreased by – 31%.
- The number of students with an average level increased by 4%.
- The number of students with a high level increased by – 35%.

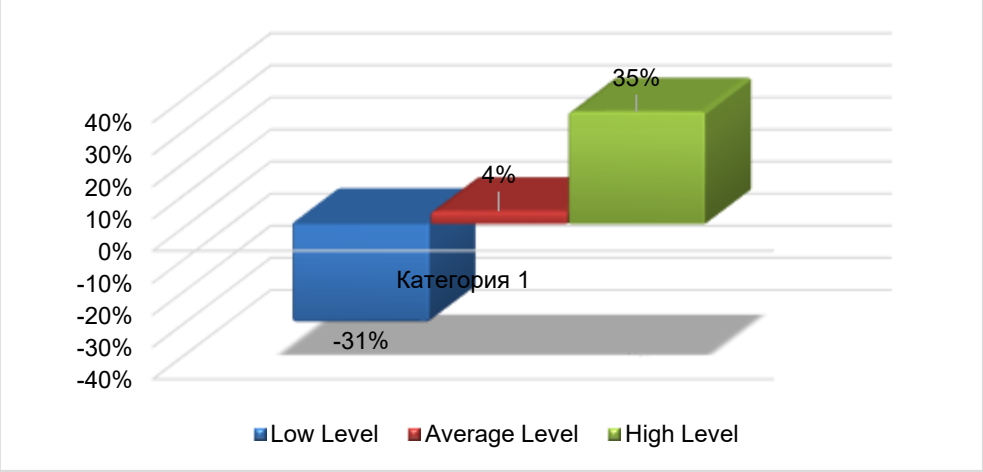


Figure 3. Changes in Students' Success Levels and Information and Digital Competence Indicators During the Control Experiment.

During the experiment, the system was tested. It demonstrated a positive impact on students' professional training, effectively contributing to the development of information and digital competence among future specialists and increasing their success.

Interpretation of results and statistical analysis

Samples for homogeneity, i.e., equality/similarity, allow us to evaluate the analysis of variance. The average values of each sample are compared with each other. In a one-factor analysis of variance, the overall significance of differences is calculated.

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For respondents, questionnaires were developed based on previously defined indicators of information and digital competence. A 100-point scale was used to assess each indicator's achievement.

All students who participated in the experiment were evaluated. The average value of all indicators was used to create a conjugation table.

According to this principle, the values were clustered:

- From 1 to 62 points − students have a low level of information and digital competence.
- From 63 to 87 points − students have an average level of information and digital competence.
- From 88 to 100 points − students have a high level of information and digital competence.

Thus, to assess information and digital competence, we grouped the results into three levels based on the quality of learning during the educational activity. Also, assuming there are no differences between the experimental groups, the expected frequencies for the levels of information and digital competence are:

Let us formulate the null hypothesis H0 in order to test the first assumption: the use of the developed system does not affect the level of information and digital competence, that is, the changes in the variable SK are random.

Let us formulate an alternative hypothesis, H1, in order to test the assumption: the use of the developed system significantly affects the level of information and digital competence, that is, the changes in the variable SK are not random.

We use the Pearson χ^2 consistency criterion for quantitative confirmation. If the obtained statistics exceed the quantile of the χ^2 distribution, then the null hypothesis H0 is rejected. If not, the hypothesis is accepted at the 0.05 significance level.

The calculated value of the Pearson criterion is greater than the critical one for 6 degrees of freedom: 40.021>12.592. The value of asymptotic significance also indicates this and determines the probability of error when rejecting the null hypothesis. As a result, we accept the alternative hypothesis that the system we developed affects the assessment of information and digital competence levels.

The existing data from the one-way analysis of variance for the experiments yield a value of 22.015, which is Fisher's exact test (F-test). The corresponding critical value of the F-test at degrees of freedom (4-1) = 3 for the between-group (variance) and at degrees of freedom (388-4) = 384 − within-group and at a significance level of $\alpha = 0.05$ is 2.628. Therefore, the calculated Fisher's exact test statistic for the experimental data exceeds the critical value: 22.015 > 2.628. Therefore, the proposed null hypothesis regarding the differences that are random in the group means was rejected, and the alternative hypothesis was accepted: the values of the general means differ significantly. That is, the actual data do not agree with the null hypothesis; therefore, the null hypothesis of the analysis of variance is rejected as a result – that is, a factor acted over the years, which determined the difference in success, the absence of the effect of the factor under consideration. Based on the positive results of the analysis of variance, we can conclude that the level of training in the developed system affects students' educational outcomes.

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We were interested in the influence of individual levels of the factor. For this, we used a posteriori tests – the results of comparisons of pairwise levels of the independent variable. We used the Tukey criterion – a criterion of true significance, which, to determine differences between groups, uses the Student's t-statistic and controls the frequency of results that are false positives with correction for the effect of multiple comparisons.

The table of one-way analysis of variance for experiments gives us a value equal to 11.5 F-criterion (Fisher's criterion). The corresponding value of the F-criterion, which is critical at α=0.05, is 3.043.

Therefore, the value of the Fisher criterion calculated from the experimental data exceeds the critical value – 882.997 > 3.043. As a result, the null hypothesis of the analysis of variance is rejected – the absence of the considered factor effect. We can state that the level of the specified competence affects learning outcomes, as shown by the results of the analysis of variance.

We, based on statistical analysis, have proven that the developed system of training future specialists of higher education by creating a digital environment for the formation of students' information and digital competence makes it possible to form a value component, a technological component, an activity component, and a reflexive component of the specified competence of future specialists. Therefore, the experiment we conducted confirmed the research hypothesis and demonstrated the effectiveness of the proposed system in developing the information and digital competence of future specialists.

Comparing These Results with Previous Studies

The findings are consistent with previous research emphasizing the importance of digital competence in higher education. Similar to Churampi-Cangalaya et al. (2024), our results confirm a positive relationship between digital competence and academic performance. The significant increase in students with a high competence level (from 14% to 48%) supports this conclusion.

The multidimensional structure of competence identified in our study (value, technological, activity, reflective components) aligns with the framework proposed by Del Prete & Cabero Almenara (2020).

Consistent with Laurente-Cárdenas et al. (2020) and Terreni et al. (2019), the results highlight the importance of structured digital learning environments. However, unlike many studies focusing on individual tools, this research provides empirical evidence of the effectiveness of a holistic, system-based digital model.

Baseline results confirming low initial competence levels correspond with Nieto-Rivas et al. (2025), while the significant improvements observed demonstrate the effectiveness of a long-term, integrated intervention.

Overall, the findings support existing literature and contribute new empirical evidence on the effectiveness of comprehensive digital environment design in higher education.

Conclusions

This study substantiated and empirically verified the effectiveness of a structured digital higher education environment designed to develop information and digital

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competence among future specialists. The research addressed the identified gap in the literature concerning the lack of integrated and experimentally validated models for competence formation within holistic digital ecosystems.

The findings demonstrate that the implementation of a system-based digital educational model significantly improves students' information and digital competence across four interrelated components: value, technological, activity, and reflective. Statistical analysis (χ^2 and ANOVA at $\alpha = 0.05$) confirmed that the observed changes were not random and that the developed digital environment had a statistically significant impact on competence levels.

The results indicate a substantial decrease in the proportion of students with a low level of competence and a corresponding increase in the proportion of students with a high level. This confirms that a comprehensive approach—combining digital infrastructure, innovative pedagogical methods (blended learning, flipped learning, project-based learning), structured LMS integration, and professional digital platforms—produces sustainable educational effects.

The study contributes to the existing body of research by providing empirical evidence of the effectiveness of a longitudinal, multidimensional, and pedagogically grounded digital transformation model in higher education. Unlike approaches focused solely on technological tools, the proposed system integrates technological, value-oriented, and reflective dimensions of competence formation.

From a practical perspective, the findings suggest that higher education institutions should adopt systemic digital environment strategies rather than isolated digital interventions. Structured digital ecosystems can serve as a foundation for preparing competitive specialists capable of functioning effectively in a rapidly digitalizing labor market.

Limitations

The study was conducted within Ukrainian higher education institutions, which may limit the generalizability of the findings to other educational contexts. Additionally, although statistical significance was established, further research could include broader international samples and additional effect size analysis.

Implications for Future Research

Future studies may focus on cross-cultural validation of the proposed model, long-term tracking of graduates' professional success, and the integration of emerging technologies (e.g., artificial intelligence and immersive environments) into digital competence development frameworks.

Overall, the results confirm the research hypothesis and demonstrate that designing and implementing a structured digital higher education environment is an effective strategy for fostering the information and digital competence of future specialists.

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Original Article

Digital technologies and professional training: The case of human interaction specialists

Tecnologías digitales y formación profesional: el caso de los especialistas en interacción humana

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Abstract

This study aims to substantiate and experimentally verify the effectiveness of integrating digital technologies and artificial intelligence (AI) into the professional training of future Human-Interaction Specialists in higher education. A quasi-experimental mixed-methods design with a pretest–posttest control group structure was conducted during 2022–2025. Participants were undergraduate and graduate students of socio-humanitarian and pedagogical specialties. Professional readiness was defined as a multidimensional construct including motivational, procedural, creative, and reflective-evaluative components. Data were collected through questionnaires, competence-based testing, creative tasks, observation, and reflective assessment. Pearson's chi-square test (χ^2; $p < .05$) was applied to determine statistical significance. At the baseline stage, most students demonstrated low readiness levels (motivational – 56%; procedural – 62%; creative – 38%). After implementing the digital pedagogical model in the Experimental Group, the proportion of students with high levels increased significantly: motivational (4%→29%), procedural (20%→47%), creative (10%→29%), and reflective-evaluative (28%→44%). Posttest χ^2 values exceeded the critical threshold (5.991), confirming statistically significant differences between groups. The findings demonstrate that a structured digital educational environment integrating AI-based tools significantly enhances professional readiness. The study empirically validates a multi-component model of readiness formation and supports the pedagogical effectiveness of AI integration in higher education.

Keywords: professional training of specialists, digital technologies, diagnostics, digitalization of the educational environment, artificial intelligence.

Resumen

Este estudio tiene como objetivo fundamentar y verificar experimentalmente la efectividad de la integración de tecnologías digitales e inteligencia artificial (IA) en la formación profesional de futuros especialistas en interacción humana en la educación superior. Se llevó a cabo un diseño cuasi experimental de métodos mixtos con una estructura de grupo de control pretest-postest durante 2022-2025. Los participantes fueron estudiantes de pregrado y posgrado de especialidades sociohumanitarias y pedagógicas. La preparación profesional se definió como un constructo multidimensional que incluye componentes motivacionales, procedimentales, creativos y reflexivos-evaluativos. Los datos se recopilaron mediante cuestionarios, pruebas basadas en competencias, tareas creativas, observación y evaluación reflexiva. Se aplicó la prueba de chi-cuadrado de Pearson (χ^2; $p < .05$) para determinar la significancia estadística. En la etapa inicial, la mayoría de los estudiantes demostraron bajos niveles de preparación (motivacional - 56%; procedimental - 62%; creativo - 38%). Tras la implementación del modelo pedagógico digital en el Grupo Experimental, la proporción de estudiantes con niveles altos aumentó

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significativamente: motivacional (4%→29%), procedimental (20%→47%), creativo (10%→29%) y reflexivo-evaluativo (28%→44%). Los valores de χ^2 del postest superaron el umbral crítico (5,991), lo que confirma diferencias estadísticamente significativas entre los grupos. Los hallazgos demuestran que un entorno educativo digital estructurado que integra herramientas basadas en IA mejora significativamente la preparación profesional. El estudio valida empíricamente un modelo multicomponente de formación de la preparación y respalda la eficacia pedagógica de la integración de IA en la educación superior.

Palabras clave: formación profesional de especialistas, tecnologías digitales, diagnóstico, digitalización del entorno educativo, inteligencia artificial.

Introduction

Modern progress in science, industry, and technology requires professionals to have a deeper understanding of their field and to acquire competencies such as teamwork, communication, and creativity. Therefore, the question of how future specialists are professionally trained in higher education, and how teachers prepare students for the challenges of the modern labor market and for societal competitiveness, becomes an important, relevant, and cutting-edge topic for discussion. The formation of professional competence in future Human-Interaction Specialists and the development of socially significant qualities in conditions that are close to production are the result of the integration of production and education, these two types of activity, each of which contributes to the solution of various tasks and the achievement of different goals (Farias-Gaytan et al., 2023).

The implementation of digital technologies in higher education has become a defining trend in contemporary pedagogy. Education continually requires the integration of technological solutions into the socio-cultural space, necessitating the adaptation of the educational process to dynamic changes in digital infrastructure. The rapid development of information technologies stimulates this need. New opportunities for effective learning and the development of students' creativity and critical thinking emerge through digital technologies, affect students' cognitive processes and teaching methods and pedagogical strategies, and are necessary to ensure their professional and social adaptation in a modern digital society (Gutiérrez et al., 2019).

In higher education, the integration of digital technologies into the training of future Human-Interaction Specialists is also linked to the regulatory and legislative requirements governing this process in society. Therefore, there is a need for a deep understanding of the specific use of digital technologies in pedagogical contexts.

In this study, the term Human-Interaction Specialists is used as an operational category referring to future professionals in socio-humanitarian fields whose core professional activity is based on direct interpersonal interaction, communication, counseling, education, and social support within institutional and community contexts. This category includes, in particular, future teachers, social workers, psychologists, special and inclusive education specialists, and other professionals whose work requires the development of communicative competence, emotional intelligence, reflective thinking, and the ability to operate effectively in digitally mediated environments.

Within the framework of this research, Human-Interaction Specialists are defined as higher education students preparing for professions in which interpersonal communication, ethical responsibility, and adaptive decision-making constitute the

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primary functional components of professional activity, especially under conditions of digital transformation.

Therefore, innovation and improvement of the pedagogical aspects of the use of digital technologies in the professional training of future specialists in higher education are critically important for developing effective modern methods of the educational process that meet the requirements of digitalized education.

Literature Review

The significance of the theory of the informatization of education, and of psychological and pedagogical research in the context of modern digitalization, is evident in the analysis of the impact of digital technologies on learning processes in higher education.

Hamdan-Mansour et al. (2026) examined the relationship between the use of artificial intelligence (AI) and health specialty students' critical thinking, clinical competence, and willingness to practice human interaction skills at Jordanian universities. Surveying 542 students with validated instruments, the study found that students generally held positive attitudes toward AI, reporting that it supported their critical thinking, general skills, and clinical competency. AI use showed significant positive correlations with critical thinking ($r = 0.42$), clinical competency, and communication skills ($r = 0.15$), although the explained variance was modest (R^2 ranging from 2.4% to 17.3%). The findings highlight the potential of integrating AI into health education to enhance students' analytical, clinical, and communication capabilities, supporting its inclusion in curricula and pedagogical strategies.

Hamdan-Mansour et al. (2026) discuss the implications of perceiving artificial intelligence (AI) as conscious in human-AI interactions. The authors argue that whether AI is inherently conscious is less relevant than the fact that users often treat AI as if it were conscious, which can influence subsequent human-human interactions. This "carry-over effect" occurs because interacting with humanlike AI – such as chatbots, digital assistants, or social robots – activates mental schemas similar to those used in human interactions, shaping behavior and perceptions toward other people. The paper reviews evidence from human-computer and human-AI interaction studies and explains how schema activation can be measured as a driver of these effects. Ultimately, the study suggests that the design and regulation of AI should account for its perceived consciousness to manage behavioral outcomes. At the same time, moral considerations for AI may also be relevant, irrespective of its actual sentience.

Beyan et al. (2023) provide a comprehensive survey on automated analysis of co-located human–human interactions using nonverbal cues. Covering studies since 2010, the review examines how social traits (e.g., leadership, dominance, personality), social roles, and interaction dynamics (e.g., engagement, rapport, group cohesion) are detected through computational methods. The authors highlight commonly used cues and techniques, such as speaking activity, support vector machines, and meeting scenarios with microphones and cameras, while noting that multimodal features and deep learning architectures generally improve performance. The survey also identifies gaps, including the lack of scalable benchmarks, inconsistent annotation reliability, few cross-dataset experiments, and insufficient explainability. Additionally, the paper summarizes relevant datasets and outlines future directions, emphasizing AI implementation, dataset curation, and privacy-preserving interaction analysis.

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Shen & Wang (2023) investigated how social skills influence lexical alignment – the tendency to match a conversational partner's word choices – in human-human (HHI) versus human-computer interaction (HCI). Using a speech-based picture naming and matching task with social skills measured by the Chinese University-students Social Skill Inventory (ChUSSI), the study found that lexical alignment was stronger in HCI (79.5%) than in HHI (58.6%). Notably, participants' concern for their partner's social standing (Partner's Mianzi) significantly predicted alignment in HHI but not in HCI, indicating that social considerations influence language behavior only when interacting with humans. These results highlight a boundary in how individuals cognitively represent human versus computer interlocutors, suggesting that social cues play a limited role in HCI.

The rapid integration of digital technologies and artificial intelligence (AI) into higher education has stimulated extensive interdisciplinary research. However, the pedagogical mechanisms explaining *how* learning occurs within AI-mediated environments require clearer theoretical grounding. To address this gap, the present study integrates digital transformation research with contemporary learning theories, particularly self-regulated learning, connectivism, and competence-based education.

The theory of **self-regulated learning (SRL)** explains how learners actively plan, monitor, and evaluate their cognitive and motivational processes. Digital tools and AI-based adaptive systems enhance SRL by providing immediate feedback, personalized learning trajectories, and progress tracking mechanisms. Intelligent tutoring systems, automated assessment, and chatbots support metacognitive reflection and formative feedback, thereby strengthening reflective-evaluative components of professional readiness. Empirical research demonstrates that AI-supported environments foster critical thinking and self-monitoring skills when aligned with pedagogical objectives rather than purely technical functionalities.

The concept of **connectivism**, proposed in the context of networked digital environments, emphasizes learning as the ability to construct and navigate knowledge networks. From this perspective, digital platforms, social networks, and AI-driven recommendation systems function as nodes within an expanded cognitive ecosystem. Learning occurs through interaction, collaboration, and access to distributed knowledge sources. Thus, the use of learning management systems, collaborative tools, and AI chatbots aligns with connectivist principles by enabling dynamic knowledge exchange and continuous professional development.

Within the **competence-based approach**, professional training is viewed as the formation of integrated cognitive, practical, motivational, and reflective components. Digital technologies facilitate competence formation by simulating professional contexts, modeling real-life scenarios, and supporting adaptive problem-solving. AI-driven simulations and virtual environments create conditions for experiential learning, which is particularly relevant for Human-Interaction Specialists whose professional effectiveness depends on communication, adaptability, and ethical decision-making.

Previous empirical studies highlight the growing impact of AI in education. Research demonstrates positive correlations between AI use and the development of critical thinking and communication skills (Hamdan-Mansour et al., 2026). Systematic reviews of AI in higher education emphasize personalization, automated feedback, and adaptive learning as key pedagogical affordances (Ouyang et al., 2022). Studies on chatbot interaction further reveal that perceived social presence influences

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engagement and learning outcomes (Chaves & Gerosa, 2021). However, highly technical analyses of human–computer interaction (e.g., lexical alignment or nonverbal cue detection) often lack pedagogical contextualization, which limits their applicability to professional training models.

Therefore, integrating AI tools into professional education requires alignment with established learning theories. AI should not be conceptualized solely as a technological innovation but as a pedagogical instrument that supports self-regulation, networked learning, reflective practice, and competence development. This theoretical integration provides the conceptual justification for selecting digital tools in the present study and explains the mechanisms through which they influence the formation of professional readiness in future Human-Interaction Specialists.

Purpose of the article. Improving the professional training of future Human-Interaction Specialists using digital technologies in higher education.

Methodology

Research Design

This study employed a quasi-experimental mixed-methods design with a pretest–posttest control group structure. The research aimed to determine the effectiveness of pedagogical conditions and digital technologies (including artificial intelligence tools) in enhancing the professional readiness of future Human-Interaction Specialists.

The design included both quantitative (diagnostic measurements, statistical testing) and qualitative components (observation, reflective analysis). The intervention model was implemented over three academic years (2022–2025).

Participants (Sample)

The study involved N = 128 students enrolled in socio-humanitarian and pedagogical specialties at three Ukrainian higher education institutions. The participants were undergraduate (3rd–4th year) and graduate (1st year Master's) students preparing for professions classified in this study as Human-Interaction Specialists (teachers, social workers, psychologists, and specialists in inclusive education).

Participants were divided into two groups:

– Experimental Group (EG): n = 64
– Control Group (CG): n = 64

Group assignment was based on intact academic groups to preserve the natural educational setting. Baseline equivalence between the EG and CG was verified using Pearson's chi-square test ($\chi^2emp < \chi^2crit = 5.991$; $p > .05$), confirming no statistically significant differences in readiness levels prior to the intervention.

The gender distribution reflected the typical demographic profile of socio-humanitarian specialties (approximately 78% female, 22% male). The average age of participants was 20.8 years (SD = 1.4).

Inclusion criteria:

– Enrollment in a socio-humanitarian or pedagogical program.

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- Participation in digital learning courses during the study period.
- Voluntary informed consent.

Exclusion criteria:

- Incomplete participation in diagnostic procedures.
- Absence during either pretest or posttest measurements.

Participation was voluntary, and all respondents provided informed consent. Data were anonymized in accordance with ethical standards for educational research.

Conceptual Framework and Variables

The study was grounded in digital transformation theory in higher education and competence-based professional training models.

Independent Variable: Implementation of pedagogical conditions integrating digital technologies and AI tools.

Dependent Variable: Level of professional readiness for activity in a digital educational environment.

Professional readiness was operationalized as a multidimensional construct comprising four components: motivational, procedural, creative, reflective-evaluative.

Each component was measured at three levels: high, average, and low.

Instruments and Measures

A set of validated diagnostic tools was developed based on theoretical analysis and expert evaluation.

Quantitative Instruments:

- Structured questionnaires (motivation, digital readiness)
- Diagnostic testing (procedural competence)
- Creative problem-solving tasks
- Reflective-evaluative ranking scales

Qualitative Instruments:

- Systematic observation
- Structured interviews
- Reflective written self-assessments
- Portfolio analysis

Content validity was ensured through expert review. Construct validity was supported by alignment between theoretical definitions and operational indicators.

Procedure

The research was conducted in four stages:

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Stage 1 – Theoretical and Analytical Phase

A systematic literature review was conducted to establish theoretical foundations.

Stage 2 – Ascertaining Phase (Pretest)

Baseline diagnostics were performed to determine initial readiness levels across all four components.

Stage 3 – Formative Intervention Phase

The Experimental Group was exposed to a structured pedagogical model including:

- Learning Management Systems (Moodle, Google Classroom)
- Interactive digital simulations and role-play modeling
- AI-based adaptive learning systems and chatbots
- Personalized digital assessment tolos
- Electronic portfolios
- Gamified learning elements

The Control Group continued traditional instruction.

Stage 4 – Control (Posttest) Phase

Post-intervention diagnostics were administered using identical measurement instruments.

Data Analysis

Quantitative data were analyzed using inferential statistics.

Pearson's chi-square (χ^2) test for independence was applied to compare distributions across readiness levels.

Significance level was set at $p < .05$.
Degrees of freedom ($df = 2$).
Critical value: $\chi^2crit = 5.991$.
At the ascertaining stage:
$\chi^2_{emp} < \chi^2_{crit}$, indicating no significant differences between groups.

At the posttest stage: $\chi^2_{emp} > \chi^2_{crit}$ across all readiness components, demonstrating statistically significant improvements in the Experimental Group.

Descriptive statistics (percentage distributions) were also used to assess dynamic changes.

Reliability and Validity

Internal consistency was ensured through standardized administration procedures.

Content validity was confirmed by expert panel review. Statistical validity was supported by inferential analysis. Construct reliability was ensured by multi-component operationalization.

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Ethical Considerations

The study adhered to ethical standards for educational research:

- Voluntary participation
- Informed consent
- Confidentiality and anonymity
- Transparent data processing
- No personal identifiers were collected.

Results and Discussion

The content and importance of the use of digital technologies in higher education; innovative approaches to the formation of the structure and content of training; and the identification of a system of principles and methodological requirements that underpin the training of Human-Interaction Specialists.

New organizational forms of work, flexible automated production processes, and the widespread use of digital technologies have significantly altered the professional training of a modern specialist. The modern labor market is changing the requirements for the professional qualifications of Human-Interaction Specialists, requiring greater versatility in their professional functions and the use of digital technologies in their activities. This is because digital technologies, whose importance is constantly growing, serve as the intellectual core and functional components of other technologies. The use of digital technologies significantly increases the efficiency of other technologies while simultaneously reducing costs and resource use across society. In training Human-Interaction Specialists, digital technologies in higher education serve to achieve educational goals. The need to improve the quality of training future Human-Interaction Specialists, in particular, the formation of professional competence in students, requires the introduction of more effective methods of organizing the educational process and training in the educational sector. The creation of an educational environment in a new digital format is essential to training competitive specialists for the labor market, who require modern professional competencies and continually develop professionally significant qualities throughout their lives (Xia et al., 2025).

It is the mastery of digital technologies that makes specialists' professional activities more productive and effective, as it enables the use of digital, innovative, and interactive methods of teaching and learning. In the modern educational environment, information support should be at a sufficiently high level to enable a Human-Interaction Specialist to address all educational and training tasks effectively and efficiently.

This study substantiates the need for integrating digital technologies into higher education and outlines key principles guiding the training of Human-Interaction Specialists.

- The principle of integrated systematicity ensures the comprehensive development of professional competence through interconnected digital platforms, interdisciplinary tasks, and coordinated educational elements.
- The principle of professional orientation aligns training with labor market demands by incorporating simulations, virtual environments, case-based

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learning, and collaboration with employers to provide practice-oriented experience.
- The principle of integrativity promotes a holistic educational system that combines theoretical and practical components through digital simulations, interactive tools, and assessment systems.
- The principle of interactivity establishes students as active participants in learning through discussions, group projects, gamification, and problem-based activities that foster creativity and critical thinking.
- The principle of individualization supports personalized learning paths via adaptive platforms, digital consultations, and progress-tracking assessment systems.
- The principle of social responsibility ensures ethical use of digital tools, data protection, inclusivity, and equal access to educational resources.
- Finally, the principle of reflection emphasizes systematic self-assessment supported by e-portfolios and digital feedback tools, promoting metacognitive awareness and continuous professional development (Chaves & Gerosa, 2021).

Classification of digital tools that allow teachers to create conditions for high-quality professional training and diagnostics of future Human-Interaction Specialists in the educational electronic environment of higher education. Application of artificial intelligence to improve the quality of higher education.

Let us consider digital tools that are necessary for the educational activity of future Human-Interaction Specialists in the educational environment, which are classified in several areas:

- Social networks, such as Instagram, LinkedIn, Facebook, Clubhouse, Twitter, Ning, Academia.edu, play an important role in the exchange of experience between scientists and students and the establishment of professional contacts.
- Learning Management Systems, such as Google Classroom, Canvas, Moodle, Blackboard, and WebCT, contribute to the implementation of educational processes and support the implementation of online courses at various levels.
- Interpersonal communication tools: Viber, ZOOM, Telegram, Skype, Discord, WhatsApp, which provide modern communication between participants in the educational process.
- Tools for interaction, publication, sharing, including video lectures, YouTube, e-books, podcasts, Wikis, Google documents, Blogs, Mind Maps, social bookmarks, which facilitate knowledge sharing and collaboration.
- Mobile applications, software for mobile devices (tablets and smartphones), which facilitate learning anywhere and at any time.
- Virtual reality programs and online games, as well as virtual laboratories for real-time work, allow controlled experiments and the reproduction of real-world conditions.
- Content aggregation tools, such as Google Reader, NetVibes, and RSS feeds, help organize and quickly collect text data.
- Feedback and assessment systems, such as electronic testing through Moodle, Google Forms; electronic note-taking and reflection systems, such as Trello, Pages, Evernote (Tzirides et al., 2024).

Such a classification in the modern digital world underscores the importance of digital technologies in preparing students for active professional practice and the development of professional competence. These digital tools have the potential to increase the flexibility of learning and its effectiveness for future Human-Interaction Specialists, allowing teachers to adapt educational materials to students' individual

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needs and to support their active participation in the educational process. Such individualization and adaptation of learning contribute to the deep assimilation of professional material but, at the same time, pose new challenges to the educational system and require the provision of appropriate technical support and high-quality, modern teacher training for the effective use of digital technologies. The integration of digital technologies into higher education introduces innovations into educational processes and methods. The use of these technologies radically modifies the educational context, expanding educational opportunities by increasing the availability of materials and interactive tools and by individualizing the educational process (Ciampi et al., 2025).

A property of intelligent systems is artificial intelligence, which enables students to perform creative functions characteristic of the individual by acquiring knowledge, interpreting external data appropriately, and adapting to innovations to achieve specific goals (Mytnyk et al., 2024).

In the modern world, the use of artificial intelligence in the professional training of Human-Interaction Specialists is highly relevant. The following key capabilities of modern technology emphasize the importance of artificial intelligence:

- Ensuring the accessibility of artificial intelligence is a valuable tool for those who lack physical access to training and for providing education to those with limited opportunities.
- Adaptation to learning, different teaching styles – can adapt to the skills of applicants, different learning styles, supporting them;
- Personalized learning contributes to improved outcomes and enables the creation of individualized educational programs that enhance learning effectiveness, taking into account each applicant's educational level and needs.
- Digital skills training – the use of artificial intelligence in education helps applicants in the educational space to assess their capabilities and limitations, learn to use technology, and modern innovations.
- Teacher support – artificial intelligence can help teachers manage their classrooms, automate administrative tasks, and provide analytical data for research.
- Innovation and research: artificial intelligence is an area of active research that stimulates innovation in education and promotes the development and implementation of new technologies.
- Forecasting and analysis: artificial intelligence helps analyze educational data volumes, improve educational programs, enable universities to predict trends, and identify problems in education (Bonami et al., 2020).

Artificial intelligence is widely used in higher education, including personalized learning, automated assessment of academic achievement, adaptive learning, interval learning with the ability to provide personalized assistance, response analysis, and evaluation, among other applications.

Voice assistants and chatbots play a major role in this, as they enable productive and personalized online learning and simplify it (Ouyang et al., 2022).

In higher education, the use of a chatbot is important for creating a favorable environment for studying professional disciplines, due to its high potential in the field of education, as the convenience of using a chatbot has been proven, since access to it is available at any time. Students felt more confident working with a bot than working with a live teacher (Haristiani, 2019).

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The most popular chatbot today is ChatGPT. In personalized, adaptive learning, scientists focus on the advantages of its use (Rudolph et al., 2023). Using ChatGPT provides high-quality feedback, enhances study at the higher education level, offers its own advice, and can serve as a partner in conversations about improving professional mastery (Bin-Hady et al., 2023).

Artificial intelligence technologies are currently actively used in higher education. Let us note the main directions in the educational process of training specialists using artificial intelligence:

- Some electronic learning assistants create personalized tasks and interactive training sessions by using artificial intelligence.
- Systems for tracking the progress of future Human-Interaction Specialists help identify the strengths and weaknesses of the system and analyze the automated assessment of tasks, ensuring an objective and rapid assessment of students' knowledge levels (Chu et al., 2022).
- Support for individuals with special educational needs – the ability to support students with special educational needs by providing tools and adaptive learning materials.
- Virtual simulations and labs – using artificial intelligence, universities are creating virtual environments for simulations and experiments, allowing students to learn in more accessible and safe conditions.
- Large-scale education and online courses – platforms such as edX, Coursera, and Udacity are using artificial intelligence to deliver online courses worldwide and to expand access to higher education for students (Farrokhnia et al., 2024).

Organization of the study

The study was conducted from 2022 to 2025 and covered the following stages.

At the first theoretical stage, a review of the literature on research issues was conducted to determine the study's theoretical foundations and experimental basis.

At the second, exploratory stage, the goal was determined; a theoretical justification of scientific provisions was carried out; an ascertaining study was carried out, a methodology and program of the experiment were developed – the formative stage. In the third experimental stage, the effectiveness of the pedagogical conditions for training future Human-Interaction Specialists was tested.

At the fourth, generalizing stage, the study's results were systematized, general conclusions were formulated, and research prospects were determined.

The development of readiness among future Human-Interaction Specialists for professional practice was characterized as a dynamic, complex process of continual change in a digitalized society. The following criteria were included in the assessment of the quality of such training:

- Motivational criterion.
- Practical criterion.
- Creative criterion.
- Evaluation criterion.

The content characteristics of the criteria and their indicators for assessing readiness for professional activity among future Human-Interaction Specialists were

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developed, reflecting the component structure of the studied object and the levels of personal development (high, average, low).

The components of readiness are prescribed as motivational, procedural, creative, and reflective-evaluative.

The results of long-term observations, theoretical research, and experiments made it possible to develop pedagogical conditions for professional training in a digitalized society for future Human-Interaction Specialists, such as: creating an emotional and positive environment using digital technologies; the development of the innovative potential of Human-Interaction Specialists and the creative richness of the content of the digital environment of higher education; methodological literacy of students in organizing the digital environment of higher education and in implementing the system of professional training of specialists; scientific and methodological digital support for Human-Interaction Specialists, which determines the effectiveness of their professional training.

Analysis of the state of readiness of future Human-Interaction Specialists for professional non-standard activities in the digital environment of society.

The methodological and theoretical foundations of professional training for the selected professional activity, Human-Interaction Specialists, developed during the research necessitated experimental work.

The purpose of the experimental work at the ascertaining stage was to present the results of diagnosing the level of readiness of future specialists for non-standard professional activity in the digital environment.

The results of the diagnostics of students' creative digital abilities at the beginning of the experimental study showed the following levels of students' creative abilities: The reproductive level of students' creative abilities was − 38%.

The practical level of students' creative abilities was − 52%.
The level of students' creative abilities was −10%.

The results of the questionnaire at the ascertaining stage showed that most students are prone to stereotyping when performing educational tasks, subjective views dominate in the organization of educational activities, in the assessment of their actions, we observe a lack of technological tools, and the implementation of digital technologies into the content of education is at a low level.

Analysis of the professional training of future Human-Interaction Specialists indicates a gap between the actual development of students' digital competence and their perceptions of productive professional activity in society's digital environment.

Table 1.
Levels of formation of components of readiness of future specialists for non-standard activity in the digital environment at the ascertaining stage of the pedagogical experiment (%)

Readiness components	Low Level	Average Level	High Level
	%	%	%
Motivational	56%	40%	4%
Procedural	62%	18%	20%
Creative	37%	53%	10%
Reflective-evaluative	39%	32%	29%

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At the stage of experiment design, based on the diagnostic results, we formed an experimental group and a control group.

The experimental group included the following groups of students, in which relatively lower results were observed in the control sections.

In the control group (CG), student professional training was conducted according to the traditional method. In contrast, in the experimental group (EG), training was conducted according to the developed pedagogical conditions and an innovative method.

The hypothesis of the presence of statistically significant differences between the level of training of students of the experimental and control groups at the stage of the ascertaining experiment was tested using the χ^2 – Pearson criterion.

As the null hypothesis H_0, the statement was chosen: “The level of training of respondents of the experimental and control groups at the stage of the ascertaining experiment has statistically significant differences”.

As the alternative hypothesis H_1, the statement was accepted: “There are no statistically significant differences in the level of training of respondents of the experimental group and the control group at the stage of the ascertaining experiment”.

During the ascertaining stage of the experiment, diagnostic studies were conducted on the level of formation of each of the structural components of the readiness of future Human-Interaction Specialists for professional activity in the digital society, which allowed us to say that the vast majority of respondents have an insufficient level of formation of the studied personal formation.

Therefore, the developed pedagogical conditions for professional training in a digitally transformed society for future Human-Interaction Specialists were implemented in the EG.

The key aspects of the use of digital technologies in higher education in the EG were the ability to expand and enrich traditional forms of the educational process, including interactivity, digital tools, multimedia materials (virtual laboratories and simulations), and open educational resources and online courses.

The use of open educational resources enabled us to offer EG respondents a flexible and accessible educational system, which was significant for the digitalization of higher education and the context of globalization. This allowed students to choose from a wide range of educational components, regardless of their financial capabilities or location. Digitalization of education has brought innovations to the training of future EG specialists through the personalization of the educational process.

The use of artificial intelligence in EG had a significant impact on the development of higher education by adapting the educational process to the individual needs of future Human-Interaction Specialists, thereby significantly increasing the quality of higher education. The use of artificial intelligence in higher education had an important practical significance and scientific basis, as it contributed to ensuring interactivity, adaptability, and personalization of the educational process, allowed the teacher to choose the optimal format of training, develop a high-quality course and promptly correct it, offer students innovative ways to assess the level of

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assimilation of educational material, etc. The use of artificial intelligence in higher education has created significant opportunities for addressing this issue.

After completion of the formative stage of the experiment, analysis of the results across all components indicated positive trends.

Let us show it step by step.

The motivational component of readiness for professional non-standard activities in the digital environment among EG students, compared with CG students, was examined first. We assumed that if at the stage of the ascertaining cut the value of the statistical criterion $\chi^2_{emp} < \chi^2_{crit}$ for the motivational component was obtained (2.171 < 5.991), then this indicates the absence of differences in the formation of this component, which is a significant sign of interest in EG and CG students, then after the completion of the formative stage of the experiment, statistically significant differences in the results (8.582 > 5.991) are transferred to the category of statistically significant differences in the results (8.582 > 5.991), since at this stage $\chi^2_{emp} > \chi^2_{crit}$.

Table 2.
Dynamics of the levels of formation of the motivational component of students' readiness for activities in the digital environment at the formative stage of the pedagogical experiment (%)

Level of formation	Motivational component			
	Ascertaining stage		Formative stage	
	CG	EG	CG	EG
High Level	4%	4%	8%	29%
Average Level	40%	39%	48%	54%
Low Level	56%	57%	44%	17%

At the control stage of the study, to determine the extent of the formation of the procedural component of readiness for non-standard professional activity in the digital environment, students were presented with various tasks designed to assess their knowledge of a professional field in the modern digital society. At the level of tasks, respondents were offered reproductive-type tasks – they were offered to evaluate their own professional actions that take place in the digital environment of professional activity. While performing productive tasks, the EG respondents demonstrated their vision for solving professional problems. We observe in the EG the manifestation of non-standard thinking among respondents in solving problems in education and the workplace.

The results obtained are reflected in Table 3.

Table 3.
Dynamics of the levels of formation of the procedural component of students' readiness for activity in the digital environment at the formative stage of the pedagogical experiment (%)

Level of formation	Procedural component			
	Ascertaining stage		Formative stage	
	CG	EG	CG	EG
High Level	19%	20%	23%	47%
Average Level	18%	18%	29%	36%
Low Level	63%	62%	48%	17%

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The results presented in the table indicate that respondents in both groups (CG and EG) exhibited low levels of formation at the stage of ascertaining the procedural component of readiness. χ^2_{emp}=1.443 − according to the calculated statistical empirical criterion, this value is less than the critical χ^2_{crit}=5.991. At the initial stage of the experiment, respondents in the EG and CG groups did not differ significantly in the degree of formation of the procedural component of readiness.

We observed positive dynamics following completion of the formative experiment in EG students, indicating the development of creative abilities.

AFTER the completion of the experimental program, the value of the Pearson statistical criterion indicates the presence of significant statistical differences between the results of EG and CG students in the levels of formation of the procedural component (versus χ^2_{crit}=5.991 − criterion χ^2_{emp}=7.577).

To assess the extent of the creative component of readiness, respondents were given test papers containing tasks at the reproductive, productive, and creative levels.

Reproductive-type tasks: students at this level were required to evaluate their own professional actions and those of colleagues in traditional practice within the specialty.

Productive type tasks: students expressed their own thoughts on solving a professional problem.

Creative-type tasks involved non-standard problem-solving and creative actions. The results of the experiment are shown in Table 4.

Table 4.
Dynamics of levels of formation of the creative component of students' readiness for activity in a digital environment at the formative stage of the pedagogical experiment (%)

Level of formation	Creative component			
	Ascertaining stage		Formative stage	
	CG	EG	CG	EG
High Level	9%	10%	15%	29%
Average Level	53%	52%	59%	63%
Low Level	38%	38%	26%	8%

Table 4 shows that, at the ascertaining stage of the experiment, respondents in the CG and EG groups exhibited a low level of formation of the creative component of readiness.

χ^2_{emp}=1.4454 according to the calculated statistical empirical criterion, this value is less than the critical χ^2_{crit}=5.991. The EG and CG groups did not show significant differences at the initial stage of the experiment in the level of formation of the creative component of readiness.

We observed positive changes in EG respondents' creative abilities following completion of the experiment's formative stage.

The value of the Pearson criterion, which is statistical, indicates the presence of statistically significant differences after the completion of the experimental program

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between the results of the respondents of the EG and CG in the levels of formation of the creative component of readiness (versus χ^2_{crit}=5.991− criterion χ^2_{emp}=7.577).

During the ascertaining and formative experiments, the level of students' formation in the reflective-evaluative component of readiness was assessed through observation, testing, and ranking. Respondents in the EG and CG were asked, in writing, to evaluate and analyze their classmates' and their own activities during the lesson. The manifestations of respondents' activity were evaluated for logical coherence, objectivity, and the ability to comment and analyze. The results are presented in Table 5.

Table 5.
Dynamics of the levels of formation of the reflective-evaluative component of students' readiness for activity in the digital environment at the formative stage of the pedagogical experiment (%)

Level of formation	Reflective-evaluative component			
	Ascertaining stage		Formative stage	
	CG	EG	CG	EG
High Level	29%	28%	30%	44%
Average Level	33%	33%	39%	51%
Low Level	38%	39%	31%	5%

It is clear that the dynamics of the levels of readiness of the reflective-evaluative component have a positive direction upon completion of the experimental program. During the experimental work, our attention was focused on tasks with a creative subtext, problem-solving conversations, role-play modeling with a practice-oriented focus, disputes, dialogues, training sessions, business games, and related activities. The work carried out ensured positive dynamics in the CG experimental program.

The creation of a creative, positively favorable digital educational environment and the implemented pedagogical conditions provided each EG student with psychological comfort and psychological security, allowed, through the use of innovative various technologies, to take into account the development opportunities of each individual, his abilities, and readiness to work in a digital environment, satisfied the personal attitudes of EG students, contributed to the development of their creative actions, and had a qualitative impact on the formation of a multi-component structure of the readiness of future Human-Interaction Specialists by means of using digital technologies in professional activities.

The present study found statistically significant increases in both creative and reflective-evaluative components of professional readiness following the integration of digital technologies and AI-based tools. Specifically, the proportion of students with high levels of creative readiness increased from 10% to 29%, and reflective-evaluative readiness increased from 28% to 44% in the Experimental Group. These results align with and extend previous research that highlights the role of technology-enhanced environments in fostering higher-order thinking and metacognitive engagement.

Several studies have reported similar effects of digital and AI-supported learning on creativity. For example, Chen et al. (2025) demonstrated that adaptive learning systems can stimulate divergent thinking by presenting scaffolded problem-solving scenarios tailored to individual learner performance. Similarly, research on simulation-based learning environments indicates that interactive digital tools provide safe spaces for experimentation, reducing fear of failure and enabling

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learners to explore novel solutions (Chaves & Gerosa, 2021). The current findings reinforce these observations, suggesting that digital affordances not only support task performance but also encourage creative exploration within professional contexts.

Regarding reflective-evaluative processes, our results corroborate the work of Zimmerman (2002), whose theoretical model of self-regulated learning emphasizes reflection as a core component of metacognition. AI-driven feedback mechanisms and automated progress tracking in this study likely supported students' ability to monitor and evaluate their own learning performance – an effect also documented in recent empirical research by Khasawneh et al. (2025), who found that learners using AI-enhanced e-portfolios engaged more consistently in reflective practice than those using traditional assessment formats.

However, some previous studies have reported more modest effects on reflective engagement, particularly when digital tools lacked structured prompts or pedagogical framing (Chan & Lee, 2021). This suggests that technology alone is insufficient; meaningful gains in reflection require intentional instructional design that guides learners through metacognitive cycles. The present study's pedagogical model, grounded in self-regulated learning and connectivist principles, may account for the stronger reflection outcomes observed, indicating that theoretical alignment between tools and learning processes is critical.

In summary, the observed improvements in creativity and reflection largely confirm existing literature on the pedagogical benefits of AI-supported and digitally enriched learning environments. These results highlight that when digital tools are integrated with theoretically grounded instructional strategies, they can effectively foster complex cognitive processes essential for professional readiness.

Conclusions

This study substantiates a theoretically grounded and empirically validated model for integrating digital technologies and artificial intelligence (AI) into the professional training of future Human-Interaction Specialists. The original contribution of the research lies in the development and experimental verification of a multi-component structure of professional readiness (motivational, procedural, creative, and reflective-evaluative), operationalized within a digitally transformed educational environment. Unlike predominantly technical studies of AI in education, this research integrates digital tools with pedagogical principles of systematicity, interactivity, individualization, integrativity, and reflection, thereby demonstrating how AI functions as a pedagogical instrument rather than merely a technological innovation. The empirical results confirm that structured implementation of AI-supported adaptive systems, simulations, digital assessment tools, and e-portfolios significantly enhances higher-order components of readiness, particularly creativity and reflective capacity. The study therefore contributes to the theoretical discourse on digital transformation in higher education by linking competence-based training with self-regulated and technology-mediated learning processes.

However, several limitations must be acknowledged. First, the quasi-experimental design and use of intact academic groups limit full randomization. Second, the sample was restricted to Ukrainian higher education institutions, which may affect cross-cultural generalizability. Third, the study measured short- to medium-term outcomes within the academic period, without assessing long-term professional performance. Additionally, reliance on percentage distributions and χ^2 analysis, while appropriate for categorical data, limits deeper causal modeling.

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Future research should therefore:

- Conduct longitudinal studies to examine the sustainability of AI-supported competence development.
- Expand cross-institutional and cross-cultural samples.
- Apply advanced statistical modeling (e.g., structural equation modeling) to examine causal relationships between digital tool use and competence formation.
- Investigate the impact of AI integration on critical thinking, ethical decision-making, and professional identity formation.
- Explore the differential effects of specific AI tools (chatbots, adaptive systems, generative AI) on distinct components of professional readiness.

In sum, the findings confirm that theoretically aligned and pedagogically structured integration of digital technologies can significantly enhance professional training, while also highlighting the need for continued interdisciplinary and longitudinal investigation.

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Original Article

Teacher preparation for inclusive education in higher education

Preparación docente para la educación inclusiva en la educación superior

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Abstract

The study aims to evaluate the effectiveness of structured pedagogical conditions for preparing future teachers for innovative professional activity in inclusive educational environments within higher education institutions. The relevance of the research is determined by the discrepancy between the formally declared principles of inclusive education and the insufficient level of readiness of pre-service teachers for inclusive practice. A mixed-methods quasi-experimental design was implemented involved experimental and control groups of future teachers. Readiness for innovative activity in inclusive education was conceptualized as an integrated construct comprising motivational-value, operational-activity, and reflective-evaluative components. The results of the ascertaining stage revealed predominantly low and medium levels of readiness in both groups. Following the implementation of targeted pedagogical conditions in the experimental group – including motivational support, methodological guidance, immersion in inclusive practice, application of innovative and digital technologies, and structured reflection – a statistically significant increase was observed across all readiness components ($p < .05$). The findings confirm that the systematic integration of motivational, methodological, and reflective elements within teacher education programs significantly enhances readiness for innovative activity in inclusive education. The study contributes empirical evidence to inclusive pedagogy research and provides a validated framework for modernizing teacher preparation in the context of educational inclusion and digital transformation.

Keywords: innovative activity, inclusive education, higher education institutions, teacher self-development and professional self-efficacy, technologies.

Resumen

El estudio busca evaluar la efectividad de las condiciones pedagógicas estructuradas para preparar a futuros docentes para la actividad profesional innovadora en entornos educativos inclusivos dentro de instituciones de educación superior. La relevancia de la investigación está determinada por la discrepancia entre los principios formalmente declarados de la educación inclusiva y el nivel insuficiente de preparación de los futuros docentes para la práctica inclusiva. Se implementó un diseño cuasiexperimental de métodos mixtos que involucró a grupos experimentales y de control de futuros docentes. La preparación para la actividad innovadora en educación inclusiva se conceptualizó como un constructo integrado que comprende componentes de valor motivacional, actividad operativa y evaluación-reflexiva. Los resultados de la etapa de verificación revelaron niveles predominantemente bajos y medios de preparación en ambos grupos. Tras la implementación de las condiciones pedagógicas específicas en el grupo experimental – incluyendo apoyo motivacional, orientación metodológica, inmersión en la práctica inclusiva, aplicación de tecnologías innovadoras y digitales, y reflexión estructurada – se observó un aumento estadísticamente significativo en todos los componentes

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de preparación ($p < .05$). Los hallazgos confirman que la integración sistemática de elementos motivacionales, metodológicos y reflexivos dentro de los programas de formación docente mejora significativamente la preparación para la actividad innovadora en educación inclusiva. El estudio aporta evidencia empírica a la investigación en pedagogía inclusiva y proporciona un marco validado para modernizar la preparación docente en el contexto de la inclusión educativa y la transformación digital.

Palabras clave: actividad innovadora, educación inclusiva, instituciones de educación superior, autodesarrollo docente y autoeficacia profesional, tecnologías.

Introduction

In the context of ongoing educational reform in Ukraine, inclusive education has become a strategic priority aligned with national legislation and international commitments. While regulatory frameworks and institutional policies increasingly support inclusive practices, the professional preparation of future teachers for work in inclusive classrooms remains insufficiently systematic and practice-oriented.

An analysis of teacher education curricula and preliminary diagnostic data (student surveys, self-assessment instruments, and expert evaluations) revealed a significant discrepancy between the professional demands placed on teachers in inclusive settings and the actual level of preparedness among pre-service teachers. The findings indicate that a considerable proportion of students demonstrate fragmented understanding of inclusive education principles, limited ability to apply differentiated instructional strategies, difficulties in adapting digital and methodological tools for learners with special educational needs, and low confidence in implementing individualized learning trajectories (Castillo-Acobo et al., 2022).

Therefore, the research problem lies in identifying and experimentally validating pedagogical conditions and innovative training approaches that can ensure comprehensive preparation of future teachers for professional activity in inclusive educational environments. The necessity of this study is justified by the existing gap between the formally declared principles of inclusion and the empirically observed level of competence formation among pre-service teachers. Addressing this gap requires evidence-based pedagogical solutions supported by diagnostic data and contextualized within real institutional conditions.

Literature Review

Researchers from various countries have studied the features of inclusive education and its implementation in contemporary educational settings. For our research, it is essential to consider scientists' ideas on innovative approaches to high-quality training in inclusive education for future teachers.

Núñez-Naranjo et al. (2025) examined the role of innovative digital resources in promoting digital inclusion within entrepreneurship education in Ecuador. Using a mixed-methods approach, the study analyzed the impact of these tools on secondary school students and teachers, finding that digital resources significantly enhanced technological skills and increased student engagement. The results underscore the importance of integrating digital technologies into education to foster inclusive and effective learning environments, and recommend extending such practices across other curricular areas.

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Da Silva & Franco Brandão (2024) conducted a systematic literature review on computer-supported collaborative activities as strategies for digital inclusion in youth and adult education. The review highlights persistent global inequalities in adult education participation. It identifies collaboration as a central pedagogical approach, often supported by mobile devices, social networks, and virtual learning environments due to their accessibility. The authors note a limited number of studies specifically addressing adult education, particularly in developing countries, and point out that the integration of computational thinking and artificial intelligence for digital inclusion remains underdeveloped. Overall, the study emphasizes the importance of digitally inclusive, collaborative approaches to support lifelong learning and improve educational opportunities for marginalized populations.

Ávata Varas et al. (2022) analyzed the impact of innovative educational management on inclusive, quality, and creative teaching–learning processes in a primary school context. Using a qualitative, non-experimental, and cross-sectional design based on interviews with school leaders and teachers, the study found that innovative management practices positively influence inclusive education by reducing physical, social, and cognitive barriers to learning. However, the results also revealed shortcomings in classroom practices and a lack of resources to support students with learning difficulties, highlighting the need for a shift in teachers' mindsets toward inclusive, high-quality education. Overall, the study emphasizes that innovative educational management fosters the appreciation of diversity and strengthens institutional capacity to support equitable learning opportunities.

Benoit (2020) defines innovation as encompassing all that can improve human development and quality of life. Therefore, the scientist developed activity management technologies and a unified methodological system to introduce innovations in a teacher's workplace. A targeted new training program for innovative activities of future speech therapists, based on the author's scientific and methodological system, is proposed.

Sormunen et al. (2020) propose the mandatory introduction of an information component into the structure of the innovative activity of a speech therapist or any teacher. Scientists substantiate the interconnected stages of teachers' information activity in inclusive education.

Ortega-Sánchez & Jiménez-Eguizábal (2019) implemented a set of measures to modernize the educational process within inclusive education, thereby disseminating innovative technologies for correctional and speech therapy to enable effective correction of speech disorders and to provide modern learning conditions for children with special educational needs.

Inclusive education has been widely recognized as a fundamental principle of modern educational systems, emphasizing equity, accessibility, and individualized learning support. Contemporary research highlights the importance of preparing teachers not only at the level of theoretical awareness but also in terms of practical, methodological, and digital readiness for inclusive classroom environments. However, the conceptualization and operationalization of teacher preparedness for inclusion remain heterogeneous across studies.

A significant body of research focuses on teachers' attitudes toward inclusion and general perceptions of readiness. These studies primarily employ cross-sectional survey designs and self-reported measures to assess beliefs, confidence levels, and perceived competence. While such research provides valuable descriptive insights,

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it often lacks experimental validation of specific pedagogical interventions aimed at strengthening inclusive competence.

Another group of studies examines the integration of digital technologies in inclusive education, emphasizing assistive tools, adaptive platforms, and differentiated instruction strategies. However, these investigations frequently concentrate on technological affordances rather than on systematically structured pedagogical models embedded within teacher education curricula. As a result, digital innovation is often treated as an auxiliary support mechanism rather than as a core component of competence formation.

Comparative analysis of previous research reveals three major gaps.

First, there is a methodological gap: much of the existing literature relies on descriptive or correlational designs, with limited use of quasi-experimental or experimental approaches that allow causal inferences regarding the effectiveness of pedagogical interventions.

Second, there is a structural gap: inclusive competence is often examined in isolation (attitudes, knowledge, or digital skills separately), without integrating motivational, cognitive, and activity-based dimensions into a coherent competence model.

Third, there is a contextual gap: relatively few studies provide empirically grounded evidence from Eastern European higher education systems, particularly within the Ukrainian context, where inclusive education reforms are rapidly evolving but institutional readiness remains uneven.

These gaps indicate that, despite extensive discourse on inclusive education and innovation in teacher training, there is insufficient empirical evidence regarding how structured pedagogical conditions and innovation-oriented training strategies influence the comprehensive formation of inclusive competence in pre-service teachers.

In response to these limitations, the present study aims to evaluate the effectiveness of context-specific pedagogical conditions implemented within Ukrainian higher education institutions for preparing pre-service teachers for inclusive practice. Unlike predominantly descriptive studies, this research employs a quasi-experimental design and operationalizes inclusive competence as an integrated construct encompassing motivational, cognitive, and activity-based components.

Thus, the contribution of this study to the existing literature is threefold:

1. Methodological contribution – providing experimentally validated evidence on the impact of structured pedagogical interventions in teacher education.
2. Theoretical contribution – advancing an integrated model of inclusive competence formation that connects digital, methodological, and reflective dimensions.
3. Contextual contribution – supplying empirically grounded findings from the Ukrainian higher education system, thereby expanding the geographical and institutional scope of inclusive education research.

Through this integrative approach, the study bridges the gap between normative discourse on inclusion and empirically verified pedagogical practice, aligning the

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identified research problem with a clearly defined and contextually grounded research aim.

Purpose of the article. The aim of this study is to evaluate the effectiveness of innovative pedagogical conditions and structured training strategies for preparing pre-service teachers to work in inclusive educational settings within Ukrainian higher education institutions.

Methodology

Research Design

The study employed a mixed-methods quasi-experimental design combining qualitative and quantitative approaches to examine the effectiveness of pedagogical conditions in developing future teachers' readiness for innovative activities in inclusive education. The research was conducted longitudinally during 2022–2025 and included three consecutive stages: ascertaining, formative, and control.

Participants

The participants were future teachers enrolled in higher education institutions in Ukraine. They were divided into an experimental group (EG) and a control group (CG). The groups were comparable with respect to age, field of study, and level of professional training. Participation was voluntary, and ethical standards of educational research were observed throughout the study.

Research Instruments

To assess future teachers' readiness for innovative activity in inclusive education, a complex of validated research instruments was used:

- Structured questionnaires to identify motivational and value orientations.
- Testing tools to assess knowledge and understanding of inclusive and corrective practices.
- Observation protocols to evaluate practical and activity-based competencies.
- Semi-structured interviews and conversations to obtain qualitative insights into professional attitudes and reflective skills.

Readiness for innovative activity was operationalized through three criteria:

- Motivational and value criterion.
- Activity criterion.
- Evaluation criterion.

Each criterion included specific indicators, and three readiness levels were distinguished: low, average, and high.

Procedure

At the ascertaining stage, a theoretical analysis of scientific sources was conducted, and the initial level of readiness for innovative activity in inclusive education was diagnosed in both groups. Based on the obtained results, pedagogical conditions and an experimental program were developed.

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The formative stage involved the implementation of the proposed pedagogical conditions exclusively in the experimental group. These conditions included:

formation of positive motivation for innovative professional activity;
scientific and methodological support of inclusive teacher training;
application of innovative methods, technologies, and forms of interaction in inclusive education.

The control group continued traditional training without targeted intervention.

At the control stage, a final assessment of readiness levels was conducted using the same diagnostic tools as at the ascertaining stage to ensure comparability of results.

Data Analysis

Quantitative data were processed using methods of mathematical statistics. The Mann–Whitney U test and the Kruskal–Wallis H test were applied to identify statistically significant differences between the experimental and control groups. The following hypotheses were tested:

H_0: There are no statistically significant differences between the EG and CG in readiness for innovative activity in inclusive education.
H_1: There are statistically significant differences between the EG and CG.

Qualitative data were analyzed through content and comparative analyses, thereby enabling triangulation of findings and enhancing the reliability of the results.

Ethical Considerations

The study complied with ethical standards for educational research. Participants were informed about the purpose of the study, anonymity was ensured, and data were used exclusively for scientific purposes.

Institutional Context

The study was conducted in three Ukrainian higher education institutions implementing bachelor-level teacher education programs (specialties: Primary Education, Special Education, and Social Pedagogy) during the national reform of inclusive education aligned with the Law of Ukraine “On Education” and the Concept of the New Ukrainian School. All participating institutions had formally introduced inclusive education policies; however, the level of methodological support, digital infrastructure, and practical training in inclusive settings varied.

The teacher preparation programs included mandatory pedagogical practice, psychological-pedagogical disciplines, and limited coursework specifically devoted to inclusive education (1–2 modules within general pedagogy courses). Prior to the intervention, no structured, competence-based model integrating motivational, operational, and reflective components of inclusive readiness had been systematically implemented.

Thus, the experimental intervention was embedded within the regular curriculum but functioned as a structured pedagogical enhancement integrated into the professional training cycle during the 3rd and 4th years of study.

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Validity and Reliability

The validity and reliability of the research instruments were ensured through several complementary procedures.

Content validity was established via expert evaluation involving seven specialists in inclusive pedagogy and educational psychology. The Content Validity Index (CVI = 0.87) confirmed strong agreement regarding the relevance and clarity of the items and their alignment with the three-component model of readiness (motivational-value, operational-activity, evaluation-reflective).

Construct validity was examined using exploratory factor analysis. The Kaiser–Meyer–Olkin index (KMO = 0.81) and Bartlett's test of sphericity ($p < .001$) confirmed data suitability. The results supported a three-factor structure consistent with the theoretical model, with factor loadings ranging from 0.62 to 0.84.

Criterion-related validity was verified through correlation with expert assessments during pedagogical practice ($r = 0.69$, $p < .01$).

Internal consistency was satisfactory (Cronbach's $\alpha = 0.79–0.88$). Inter-rater reliability (Cohen's $\kappa = 0.76$) and test–retest reliability ($r = 0.82$) confirmed the stability and consistency of the measurements.

Description of the Pedagogical Intervention

The pedagogical intervention was implemented during the formative stage of the quasi-experimental study and lasted two academic semesters (32 weeks; 180 academic hours). It was integrated into the regular teacher education curriculum (3rd–4th year) and delivered exclusively to the experimental group (EG), while the control group (CG) continued traditional training.

The intervention was structured according to a three-component model of readiness for innovative activity in inclusive education: motivational–value, operational–methodological, and reflective–evaluative.

Motivational–Value Component (6 weeks)

This stage aimed to develop professional values, inclusive attitudes, and motivation for innovative practice. Activities included seminars on inclusive education principles, analysis of authentic classroom cases, structured discussions of ethical dilemmas, and workshops focused on professional self-efficacy. Reflective journals were used to monitor changes in students' attitudes and professional orientation.

Operational–Methodological Component (14 weeks)

This stage focused on developing practical skills for inclusive teaching. The content included differentiated instruction strategies, adaptation of learning materials for students with special educational needs, use of assistive and digital technologies, and implementation of art-based inclusive methods (e.g., music, visual art, sand techniques).

Instructional formats included:

– Case-based learning.

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- Microteaching with peer and expert feedback.
- Project-based group work.
- Immersion visits to inclusive resource centers.
- Supervised laboratory observation of correctional practices.

Students designed inclusive lesson plans integrating innovative and digital tools and presented them for expert evaluation.

Reflective–Evaluative Component (12 weeks)

This stage consolidated professional self-efficacy and reflective competence. It included supervised pedagogical practice in inclusive classrooms, structured observation protocols, group supervision sessions, and guided self-analysis of teaching performance.

Each participant completed an inclusive practice portfolio containing lesson plans, reflective reports, expert feedback, and self-evaluation materials.

Implementation Control

To ensure fidelity of implementation, instructors completed preparatory methodological training and used standardized guidelines. Observation checklists and coordination meetings were employed to monitor adherence to the intervention design.

Unlike traditional training, which emphasized theoretical knowledge, the intervention systematically integrated motivational, practical, and reflective dimensions and provided structured immersion into authentic inclusive contexts. This ensured a comprehensive and competence-oriented preparation of future teachers for innovative activity in inclusive education.

Results and Discussion

Content of the concepts of the study: Effective methods and techniques, forms, and principles of cooperation in preparing for innovative activity of future teachers in an inclusive educational environment.

The teacher's readiness for inclusive activities and the development of inclusive competence are becoming the primary tasks today in creating an innovative system for training future teachers to work in inclusive classes.

Inclusive competence of future teachers in their innovative activities is defined as an integral characteristic of a teacher, which in the context of an inclusive approach affects the ability to solve professional tasks of educational activities, as an appropriate modern level of skills and knowledge in the context of inclusive education, which is necessary for the performance of professional functions; which are embodied in the ability to perform and integrate professional functions into the environment, taking into account the special needs of young people with health problems, creating conditions for self-development, self-efficacy and development.

For self-development and professional self-efficacy of the future teacher, we draw attention to cooperation with inclusive educational institutions, modeling for higher school students during laboratory and practical knowledge situations of quasi-professional activity, implementation of group, individual, and creative

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projects, and involvement of students for self-development and professional self-efficacy to participate in social design at the level of educational institutions.

Practical methods and techniques for preparing future teachers for innovative activities in an inclusive educational environment include:

- **The method of immersion in a professional environment.** In inclusive educational institutions, immersion in a professional environment is implemented, comprising the following stages: problematization of a specific aspect of the teacher's inclusive educational activities; preliminary practical and theoretical training; implementation; and reflection on new experience.
- **Projects.** Projects are prepared in microgroups or pairs. Collective discussions are held in practical classes to analyze the difficulties that arose during the project and its preparation.
- **The case study method.** The use of the case study method in higher education involves analyzing real situations that arise spontaneously and persistently in educational practice, addressing various situational tasks to help future teachers understand the psychological, physical, and social difficulties experienced by a child with special needs. A situational task, for example, “Blurred Picture,” allows students to imagine that they have taken their class on an excursion as the class teacher and that there is a child with a complex visual impairment in the classroom. Students analyze the actions of the future teacher. A problematic situation is created that poses a professional challenge for students; it immerses future teachers in the worldview of a child with a visual impairment.
- **The use of storytelling.** Storytelling techniques are well-known psychological tools that enable the retelling and composition of stories with motivational, instructional, and educational content. Storytelling provides an opportunity to teach future teachers to construct instructional stories for a group of children, both individually and collectively (individual and collective story composition). The use of storytelling in the professional training of future teachers is effective for fostering inclusive educational environments.

Familiarization with inclusive educational practices directly in educational institutions helps future teachers to exchange practical experience with specialists and fellow students, to comprehend the experience of interacting with children with special needs, and to immerse themselves in the content of inclusive activities at the rehabilitation and correctional stages.

Forms of cooperation with institutions serving children with special educational needs, including inclusive educational institutions, include master classes by specialists; participation in laboratory observations of children with special needs; and excursions that can be conducted via online videoconferences under conditions of live, direct interaction.

In higher education, when preparing future specialists to implement inclusive educational practices, it is advisable to teach algorithms that, at different stages of observation, involve constructing a teacher's action plan: observation of a special child's creative activity, play, and educational activities. Let us name the stages of such observation.

The observation stage includes visiting inclusive resource centers, correctional and rehabilitation institutions, and inclusive educational institutions to gain experience interacting with children with disabilities.

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The stage of external observation, in the context of distance learning via video recordings of specialists working with a child with a disability, provides students with an opportunity to observe teachers' practical activities in inclusive educational institutions.

The stage of reflection involves understanding new experiences in professional practice, forming an image of the teacher's future professional trajectory, developing an attitude toward self-development and professional self-efficacy, and engaging in self-improvement for work in an inclusive educational environment.

All proposed methods of practical training and methods of cooperation in preparing future teachers for innovative activities in an inclusive educational environment are based on the principles of an interdisciplinary approach, the connection of theory with practice, activity, and awareness in the educational process of students, and personal and professional self-development (Ramírez-Montoya et al., 2024).

Innovative strategies for psycho-educational support of students in inclusive education. Basic requirements for teachers. The importance of teachers' readiness to organize inclusive education. Key conditions for organizing an inclusive environment. Professional self-efficacy of a teacher.

In his professional practice, a teacher experiences difficulties in pedagogical interactions and clearly recognizes the challenges faced by children with special educational needs; therefore, he develops strategies for psycho-educational support for students. To assess the quality of the general education process, new, modern requirements are being proposed for teachers.

Among the basic requirements for the pedagogical activity of specialists, one can single out:

- Obtaining knowledge related to the psychological and pedagogical characteristics of children with special educational needs.
- The ability to prevent conflicts between children with special educational needs, as well as establish cooperation with their peers.
- Emotionally positive attitude towards the inclusion of each individual with special educational needs in educational teams.
- Mastery of techniques and methods for creating a favorable environment in an inclusive team.
- Awareness by teachers of the importance of involving children with special educational needs in the educational process (George-Reyes et al., 2025).

One of the key conditions for organizing an inclusive environment is teachers' readiness to engage in innovative activities within such an educational environment, which requires developing personal qualities and a sufficient level of professional development that, in the context of inclusive education, make their activities effective.

An important condition for innovative training of future teachers is also the development of a complex of personal qualities, specialized skills, and knowledge that encompasses anatomical and physiological aspects, psychological and pedagogical characteristics of the child, strategies, stereotypes, professional attitudes, and tactics of individual behavior. This enables teachers to effectively implement innovative, modern educational methods for children with special educational needs across various categories. Modern graduates of higher education recognize the full significance of professional activity and understand that their

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professional activity will take place within the ongoing development of the educational digital system, which is continually undergoing innovations that cover almost all aspects of the educational process. One such innovative change is the introduction of inclusive education in groups in which children with special educational needs study. Future teachers must be able to implement innovative methods, work in an integrated educational space, serve as moderators of students' educational trajectories, and possess the fundamentals of coaching, individualization, and the principles of comprehensive pedagogy. Therefore, the training of future teachers should include disciplines that provide practical, appropriate training in inclusive education.

Significant changes have occurred in pedagogical and social approaches, as well as in legislation governing the education of children with special educational needs. Further improvement of the professional training of relevant specialists and the educational and methodological base requires the introduction of inclusive education across all educational institutions to effectively develop inclusive education and ensure high-quality preparation of children for life. Therefore, teacher training should focus on the practical, theoretical, and psychological aspects of their professional activities.

An important aspect of the training of future teachers, one of the key conditions for organizing an inclusive environment in inclusive education, is their professional self-efficacy, the formation of subjective confidence of the future specialist, and not just the transfer of knowledge about nosologies.

For a teacher, professional self-efficacy is an integrative socio-psychological construct characterized by self-awareness and readiness to engage in competent, skillful educational activity. At the same time, the levels of its formation are determined so that the teacher can begin performing production functions. Therefore, professional self-efficacy is not only a systematic self-assessment of one's own ability to ensure the quality and effectiveness of subject-subject interaction in the process of learning with children at the normative level (Garcia, 2025).

Readiness in an inclusive space for innovative activity is determined by the extent to which the teacher, regardless of an individual's starting capabilities, believes it is possible to ensure the qualitative progress of each child.

Inclusive education presents unique challenges: the use of assistive technologies, the need to individualize educational trajectories, and the need to ensure psychological comfort for all participants in the educational process. In contemporary working conditions, teachers face uncertainty regarding their own competencies and high levels of stress. That is why the foundation is the development of professional self-efficacy, on which the teacher's readiness for innovation is built. A teacher's self-efficacy is his conviction in his ability to perform actions clearly and to fully and innovatively organize the educational process. These teacher positions are necessary to achieve specific goals in working with children with special educational needs (Reyes-Parra et al., 2020).

Teachers with high professional self-efficacy are more likely to experiment with assistive devices and digital technologies. They are professionals in their field and adapt educational content more quickly (e.g., by using multisensory approaches and creating alternative formats for educational activities). Moreover, vice versa – low professional self-efficacy of the teacher leads to "methodological conservatism", that

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is, it leads to fear of departing from the template, and this, in inclusive education, is unacceptable. Therefore, it is precisely the teacher's high level of professional self-efficacy, in conditions of inclusion where standard methods often do not work, that enables the teacher not to perceive difficulties as a defeat but to see them as a task that requires an innovative approach.

In parallel with the mastery of new digital technologies, the future teacher's professional self-efficacy develops. The ability to use technical tools for inclusion or specialized software automatically enhances the assessment of his professional capabilities. Thus, a teacher's professional self-efficacy is an internal driver of their innovative development, because even the use of the most modern technologies in inclusive education will remain formal without confidence in the success of one's own actions (Carmona et al., 2023).

Key aspects of professional training of future teachers for work in inclusive education – ways to modernize higher pedagogical education in the context of the specified problem.

In the gradual introduction of a comprehensive education system in higher education, an important factor is the professional training of teachers, which is aimed at supporting the development of children with SEN and their education within an inclusive environment. The system of professional teacher training provides for the use of systematically substantiated and specifically developed software that will contribute to students' preparation for life and support them in the educational environment. The preparation of teachers for inclusive activities encompasses their moral and psychological readiness to work with children with special needs and to provide them with a modern material base and new methodological materials.

Let us highlight the key aspects that are important in the professional preparation of future teachers for their work in inclusion conditions:

- Awareness, regardless of the characteristics of the child's development, of the needs and values of each individual.
- Understanding by the teacher of his role as a bearer of cultural values and responsibility for their transfer to children with special needs.
- Formation of value and professional orientations aimed at practical, innovative work with children with special educational needs.
- Recognition of pedagogical activity, its creative nature, which requires significant energy resources and spiritual resources (Reynaga-Peña et al., 2018).

Higher education institutions, in the context of the development of education and its humanistic and innovative paradigm at the contemporary social stage, face the challenge of preparing future teachers to work in inclusive educational environments alongside children with special educational needs.

In the context of the above problem, we will outline the ways of modernization of higher pedagogical education:

- Development of an innovative system of special training of personnel for work in conditions of inclusive education with children with special educational needs.
- Introduction of systematic, consultative, explanatory, and organizational and methodological work among the public, specialists of educational institutions, and parents in order to ensure the right to education of children with special needs.

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- Special training of regional and district consultants, development of provision of consultations – psychological, medical, and pedagogical on the issues of development and education of children in conditions of inclusive education with special educational needs.

The application of innovative approaches and technologies to children with special educational needs is integral to a teacher's inclusive competence.

The function of removing mental barriers to learning and enhancing the child's development is achieved through innovations in art therapy, a component of therapeutic and suggestive technology.

Let us reveal the content of the main types of art technologies that teachers most often use to work with children who need exceptional support in education:

- Musical art technologies (dance and movement techniques: rhythmic and movement accompaniment to a song, transmission of feelings through movements, poems with musical accompaniment; music therapy: merging with the rhythm of music and motor relaxation, sensory perception of music, musical and movement exercises and games, etc.).
- Visual art technologies (isotherapy: picture mandalas, fractal drawing, applications, modeling, collage, color therapy, etc.).
- Fairy tale art technology (creation of performances and fairy tales using puppets, theatricalization, games, adventures during a listened musical work, etc.).
- Sand art technology in working with children with special educational needs increasingly offers Sand Play – a game with sand.

This "world-building technique" helps children express their emotions without words and share their experiences and feelings. Sand art technology is a correctional and developmental method, a psychological and pedagogical method aimed at solving the problems of a child with intellectual developmental disorders and speech problems, because it is working with sand that helps the child to level out his emotional background, establish contact between the teacher and the child, increase the child's motivation for his activities, increase the child's interest in his activities, form self-regulation processes in each individual, increase the child's interest in activities, influence the growth of cognitive activity, the development of the child's cognitive processes, etc.

Thus, as a result of the use of the art technology method by teachers in their professional activities:

- Psychologically supportive conditions are created for the upbringing and development of children who require exceptional educational support.
- The development of the sensory-perceptual sphere, figurative-logical thinking, and spatial imagination of the child, fine motor skills of hands, and kinesthetic sensitivity is formed.
- Positive educational motivation is formed in the child.
- Educational and cognitive activities are activated in children who require exceptional educational support.
- Skills in nonverbal and verbal activities and in positive communication are developed through game activities. The use of alternative art-therapeutic and educational technologies in the educational process enables tracing the importance of the child's consistent creative development and the development

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of a creatively directed professional personality in a modern teacher (Fernández Muñoz & Durán Rojas, 2020).

Creative work guarantees recognition of the child's environment, increases his motivation, and forms self-education and self-esteem. The child becomes confident in himself when he succeeds in creative work.

Organization, stages, and methodology of experimental research

Taking into account the analyzed scientific and pedagogical sources, taking into account the existing preparation for innovative activity of future teachers in inclusive education, the structure of innovative activity, we will reveal the content of the components of readiness of future teachers for innovative activity in inclusive education identified by us in the conducted study:

- We define the motivational component of teachers' readiness to work in inclusive education as a set of stable motives, recognition of each child as a subject of corrective and educational activities, and orientation toward implementing an innovative, effective educational process.
- The operational component of teachers' readiness comprises general skills, professional knowledge, and specialized skills.
- The practical component of readiness provides a certain level of professional competence of the teacher, his integrative quality, which reveals readiness to implement developmental training, diagnostics, and personal development.)

A system of criteria and indicators has been developed to assess the readiness levels (low, average, high) of future teachers in inclusive education for innovative activities.

The motivational and value criterion has indicators:

- Motivation to introduce innovations into future professional activities.
- A value-based and positive attitude towards the chosen profession.
- Orientation towards cooperation with subjects of inclusive education and openness in the process of interaction with children.

The following indicators correspond to the activity criterion:

- The ability to creatively implement various methods of pedagogical interaction between all subjects of inclusive education.
- Knowledge of the specifics of corrective work with children with developmental disorders.
- For the effective organization of inclusion, there must be readiness to change one's own professional activities.

The evaluation criterion contains, in its essence, the following indicators:

- Readiness of teachers to apply innovations in future professional activities;
- The need for personal and professional self-development of the teacher;
- Evaluation of the results of building an inclusive educational environment and adequate analysis of professional activities.

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The ascertaining stage of the experiment.

During 2022-2025, an experimental study was conducted, comprising three interrelated stages: the ascertaining stage, the forming stage, and the generalizing stage.

A theoretical analysis of the outlined problem and the state of the problem under study was carried out at the ascertaining stage of the study; the directions of scientific research were determined; the pedagogical conditions for preparing future teachers for innovative activity in inclusive education were theoretically substantiated; a program of experimental work was developed; the components of readiness, criteria, indicators, and levels of readiness of future teachers in relation to the specified research topic were substantiated; a ascertaining stage of the experiment was conducted, which was the final stage of this experiment, and the initial levels of readiness of future teachers for professional activity were investigated.

According to the results, the following results of the ascertaining stage were obtained regarding the initial levels of readiness of future teachers (Fig. 1):

Motivational and value criterion

- 10,3% of EG respondents and 7,4% of CG respondents have a high level.
- 33,2% of EG respondents and 33,1% of CG respondents have an average level.
- 56,5% of EG respondents and 59,5% of CG respondents have a low level.

Activity criterion

- 14,3% of EG respondents and 11,6% of CG respondents have a high level.
- 32,7% of EG respondents and 55,0% of CG respondents have an average level.
- 53,0% of EG respondents and 33,4% of CG respondents have a low level.

Evaluation criterion

- 15,4% of EG respondents and 13,5% of CG respondents have a high level.
- 35,3% of EG respondents and 34,0% of CG respondents have an average level.
- 49,3% of EG respondents and 52,5% of CG respondents have a low level.

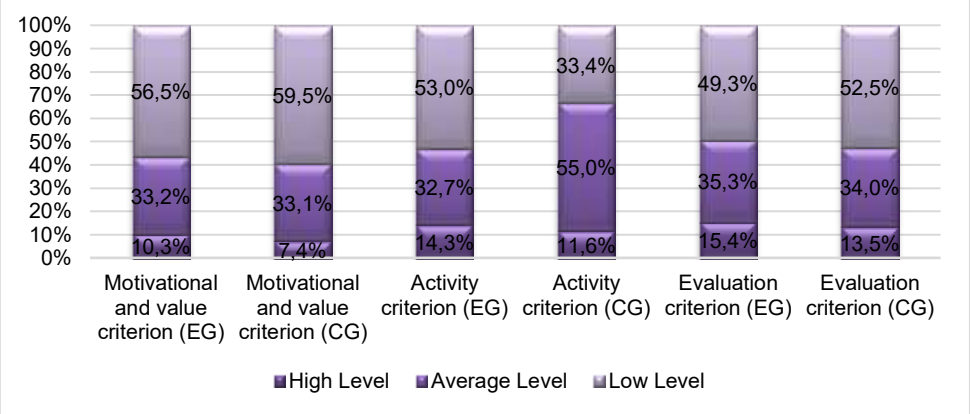


Figure 1. Initial Readiness Levels of Future Teachers by Criteria at the Ascertaining Stage.

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Having analyzed the diagnostic results on the readiness levels of future teachers at the ascertaining stage of the experiment, we conclude that future teachers exhibit low readiness for innovative activities in inclusive education.

The results of the ascertaining experiment showed the need for a formative stage.

Organization of a formative experiment to assess the readiness of future teachers for innovative activity in conditions of inclusion.

To verify the pedagogical conditions for preparing future teachers for innovative activities in inclusive education, we conducted experiments during the formative and control stages.

The research and experimental work of the formative stage was conducted in accordance with the main requirements of the pedagogical experiment, which provided for a long-term impact of the experimental means through the longitudinal method.

During the formative stage of the study, the pedagogical conditions were implemented in accordance with the experimental work program. Only students in the experimental group were administered formative measures (the traditional teaching of students in the control groups remained)

In our study, the developed pedagogical conditions were significant in successfully fostering future teachers' readiness for innovative activity within inclusive settings.

The following pedagogical conditions were effective:

- Formation of positive motivation to gain experience of the innovative nature of practical activity.
- Scientific and methodological support and resource provision of the process of training future teachers in inclusive education for innovative activities.
- Application of innovative methods, technologies, forms, and methods of interaction of all subjects of the educational process of organizing inclusive education.

All developed pedagogical conditions constitute a single complex, interconnected, and mutually conditioning set of prerequisites.

The final assessment of future teachers' readiness to work in an inclusive educational environment was conducted at the control stage of the experiment.

Using the same tools as at the ascertaining stage, an assessment of teachers' readiness for professional activity in inclusive settings was conducted.

At the control stage, qualitative and quantitative results were obtained (Fig. 2).

Motivational and value criterion

- 38,3% of EG respondents and 10,4% of CG respondents have a high level.
- 56,2% of EG respondents and 34,1% of CG respondents have an average level.
- 5,5% of EG respondents and 55,5% of CG respondents have a low level.

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Activity criterion

- 53,3% of EG respondents and 13,0% of CG respondents have a high level.
- 37,7% of EG respondents and 58,6% of CG respondents have an average level.
- 9,0% of EG respondents and 28,4% of CG respondents have a low level.

Evaluation criterion

- 48,4% of EG respondents and 14,9% of CG respondents have a high level.
- 36,3% of EG respondents and 42,0% of CG respondents have an average level.
- 15,3% of EG respondents and 43,1% of CG respondents have a low level.

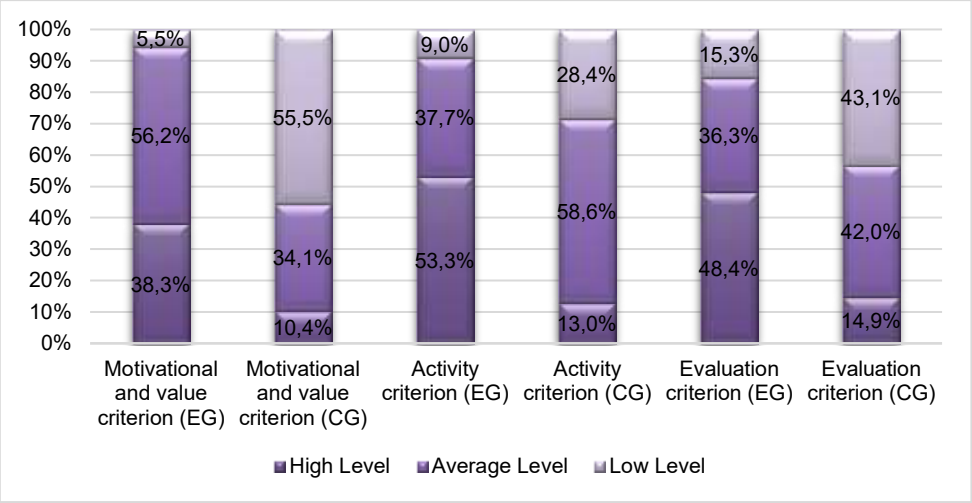


Figure 2. Readiness Levels of Future Teachers by Criteria at the Control Stage.

The results of the control section indicate that the work carried out in the EG was practical.

Motivational and value criterion – students' motivation to introduce innovations into their future professional activities has significantly increased; positive, value-based attitude towards the chosen profession; orientation towards openness in the process of interaction with children and cooperation with subjects of inclusive education.

Activity criterion – the ability to creatively implement various methods of pedagogical interaction between all subjects of inclusive education has increased; knowledge of correctional work, the specifics of working with children with developmental disorders has increased; teachers' willingness to change their own professional activities has increased.

The evaluation criterion increased teachers' readiness to apply innovations in future professional activities; the need for teachers' professional and personal self-development increased; and the level of adequate analysis of professional activities and of the results of building an inclusive educational environment increased.

In general, the dynamics of changes in the EG at the control stage are significantly more pronounced than in the CG.

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Using the Mann-Whitney and Kruskal-Wallis statistical methods, the obtained data were verified. Using the Kruskal-Wallis statistical method, we formulate hypotheses as follows in order to verify the data:

$H0$: There are no differences between the groups (EG, CG) at the control stage of the experiment, according to the results of the formation of the corresponding component (all components) of readiness.
$H1$: There are significant differences between the groups (EG, CG) at the control stage of the experiment, according to the results of the formation of the corresponding component (all components) of readiness.

Therefore, we must reject the null hypothesis based on the results of the calculations and accept the alternative one. We argue that the dynamics of change in the EG and CG differ significantly across components of readiness and, consequently, across readiness as a whole.

We also used the Mann-Whitney test in the study to test the hypotheses, which confirmed significant differences at the control and ascertaining stages of the experiment.

Compared with the critical value, the empirical values indicate non-random differences across all components of readiness in the CG and EG.

This confirms the effectiveness of the pedagogical conditions proposed by us, as significantly better results in the formation of future teachers' readiness to address the outlined inclusion problem were obtained in the EG than in the CG, where the pedagogical conditions were introduced.

The results of the study provide empirically grounded evidence that the systematic implementation of structured pedagogical conditions significantly enhances the readiness of future teachers for innovative activity in inclusive education. The positive dynamics observed in the experimental group across motivational-value, operational-activity, and reflective-evaluative components confirm the effectiveness of the proposed competence-based model.

Theoretical Interpretation of the Results

From a theoretical perspective, the findings substantiate the integrative understanding of inclusive competence as a multidimensional construct. Unlike studies that examine attitudes, digital skills, or methodological preparedness separately (Reyes-Parra et al., 2020; Da Silva & Franco Brandão, 2024), the present research confirms that inclusive readiness develops most effectively when motivational, operational, and reflective dimensions are systematically interconnected.

The significant improvement in the motivational-value criterion supports the assumption that professional self-efficacy functions as an internal driver of innovative activity (Garcia, 2025; Carmona et al., 2023). The results demonstrate that motivation for inclusive practice is not formed through theoretical instruction alone but through structured immersion in authentic professional contexts and reflective engagement.

The growth observed in the operational-activity component confirms the position of Sormunen et al. (2020) and Ortega-Sánchez & Jiménez-Eguizábal (2019) regarding the effectiveness of project-based, case-based, and technology-enhanced

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pedagogies in inclusive teacher training. However, unlike predominantly descriptive studies, the present research provides quasi-experimental evidence of causal impact.

Pedagogical Significance

Pedagogically, the study demonstrates that inclusive readiness cannot be ensured through isolated coursework or declarative knowledge. Instead, it requires:

- Systematic motivational formation.
- Structured methodological immersion.
- Guided reflective practice.
- Integration of digital and assistive technologies within authentic contexts.

The experimental model shows that teacher preparation programs must transition from predominantly theoretical delivery toward competence-oriented, experience-based training. The inclusion of art-based technologies, project-based collaboration, immersion practices, and supervised reflection contributed to the measurable increase in readiness levels.

Thus, the study confirms that innovative pedagogical conditions operate as an interconnected system rather than as isolated methodological interventions.

Academic Contribution

The academic contribution of the research is threefold:

1. Methodological contribution – the use of a quasi-experimental design with statistical verification (Mann–Whitney U and Kruskal–Wallis H tests) strengthens the evidence base in a field often dominated by correlational or survey research.
2. Theoretical contribution – the study advances an integrated model of readiness for innovative activity in inclusive education, synthesizing motivational, operational, and reflective components into a unified competence framework.
3. Contextual contribution – the research expands the empirical field of inclusive education studies by providing validated data from Ukrainian higher education institutions, thereby addressing the geographical gap identified in international literature.

Practical Implications for the Education System

The results have direct implications for:

- Curriculum modernization in teacher education.
- Development of competence-based inclusive training modules.
- Incorporation of supervised reflective practice.
- Systematic integration of digital and assistive technologies.
- Strengthening professional self-efficacy as a core training objective.

The study demonstrates that reforms in inclusive education require not only legislative support but also evidence-based restructuring of teacher preparation programs. The effectiveness confirmed in the experimental group indicates that the proposed pedagogical conditions may be recommended for broader institutional implementation.

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Final Statement

In conclusion, the study bridges the gap between normative declarations of inclusive education and empirically validated pedagogical practice. The statistically significant differences between the experimental and control groups confirm that structured, innovation-oriented pedagogical conditions substantially enhance future teachers' readiness for professional activity in inclusive environments.

While the research does not exhaust all aspects of the problem, it provides a validated theoretical and methodological foundation for further studies focused on digital transformation, interdisciplinary integration, and long-term tracking of inclusive competence development in teacher education systems.

Conclusions

The content of the research concepts is revealed. Practical methods, techniques, forms, and principles of cooperation for preparing future teachers for innovative activities in an inclusive educational environment are outlined. Innovative strategies for psycho-educational support of students in inclusive education are revealed. The main requirements for teachers are grouped. The importance of teachers' readiness for organizing inclusive learning is shown. The key conditions for organizing an inclusive environment are substantiated. The importance of a teacher's professional self-efficacy is described. Key aspects of professional training of future teachers for work in inclusive education are presented. Ways of modernization of pedagogical education in the context of the specified problem are shown. The advantages of applying innovative approaches and technologies for children with special educational needs, an integral component of a teacher's inclusive competence, are demonstrated.

During 2022-2025, an experimental study was conducted, comprising three interrelated stages: the ascertaining stage, the formative stage, and the generalizing stage.

Having analyzed the diagnostic results on the readiness levels of future teachers at the ascertaining stage of the experiment, we conclude that future teachers exhibit low readiness for innovative activities in inclusive education.

The results of the ascertaining experiment indicated the need to conduct a formative stage to assess the readiness of future teachers for innovative activity in inclusive education.

During the formative stage of the study, the developed pedagogical conditions were introduced to the students of the experimental group in accordance with the proposed experimental work program.

The results obtained in the control section indicate practical work performed in the EG.

In general, the dynamics of changes in the EG at the control stage are much more pronounced than in the CG.

Using the Mann-Whitney and Kruskal-Wallis statistical methods, the obtained data were verified. Using the Kruskal-Wallis statistical method, we formulate the hypotheses as follows in order to verify the data:

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$H0$: There are no differences between the groups (EG, CG) at the control stage of the experiment, according to the results of the formation of the corresponding component (all components) of readiness.
$H1$: There are significant differences between the groups (EG, CG) at the control stage of the experiment, according to the results of the formation of the corresponding component (all components) of readiness.

Therefore, we must reject the null hypothesis based on the results of the calculations and accept the alternative one. We argue that the dynamics of change in the EG and CG differ significantly across components of readiness and, consequently, across readiness as a whole.

We also used the Mann-Whitney criterion in the study to test hypotheses, which confirmed the presence of significant differences at the control and ascertainment stages of the experiment.

Compared with the critical value, the empirical values indicate non-random differences across all components of readiness in the CG and EG.

This confirms the effectiveness of the pedagogical conditions proposed by us, as significantly better results in the formation of future teachers' readiness to the outlined problem under inclusion conditions were obtained in the EG than in the CG, where the pedagogical conditions were introduced.

The study we conducted does not address all aspects of the problem we outlined. However, the study can serve as a basis for further research on the described problem. A promising direction for research is the development of recommendations for innovative professional activities for specialists, taking into account inclusive experience in the new conditions of society's digitalization.

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Original Article

Generative AI in the eyes of the academy: Comparative analysis of faculty and student perceptions

La IA generativa en la universidad: Análisis comparativo de las percepciones de profesores y estudiantes

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Abstract

The integration of Generative Artificial Intelligence tools such as ChatGPT, Gemini, and Claude is transforming higher education, yet little is known about how different academic stakeholders perceive these technologies within the same institutional context. This study presents a comparative analysis of faculty and student perceptions of Gen-AI in a Spanish university, based on two surveys conducted during the 2024–2025 academic year. Using a descriptive-comparative approach and independent samples t-tests, the study identifies statistically significant differences in attitudes toward Gen-AI across dimensions such as trust, ease of use, institutional support, and ethical concerns. Results show that students exhibit greater enthusiasm, confidence, and willingness to adopt Gen-AI tools, while faculty express more caution, particularly regarding reliability and pedagogical alignment. These findings underscore the need for differentiated institutional strategies that address the distinct expectations and challenges faced by both groups. These findings provide actionable insights for designing institutional strategies and training programs that foster ethical and effective integration of AI in teaching and learning.

Keywords: Educational innovation, generative artificial intelligence, higher education, perceptions, technology adoption.

Resumen

La integración de herramientas de inteligencia artificial generativa, como ChatGPT, Gemini y Claude, está transformando la educación superior, pero se sabe poco sobre cómo perciben estas tecnologías los diferentes actores académicos dentro del mismo contexto institucional. Este estudio presenta un análisis comparativo de las percepciones del profesorado y el alumnado sobre la Gen-IA en una universidad española, basado en dos encuestas realizadas durante el curso académico 2024-2025. Mediante un enfoque descriptivo-comparativo y pruebas t para muestras independientes, el estudio identifica diferencias estadísticamente significativas en las actitudes hacia la Gen-AI en dimensiones como la confianza, la facilidad de uso, el apoyo institucional y las preocupaciones éticas. Los resultados muestran que los estudiantes muestran un mayor entusiasmo, confianza y disposición a adoptar estas herramientas, mientras que el profesorado expresa más cautela, especialmente en lo que respecta a la fiabilidad y la alineación pedagógica. Estos hallazgos subrayan la necesidad de estrategias institucionales diferenciadas que aborden las distintas expectativas y retos a los que se enfrentan ambos grupos. Estos hallazgos proporcionan información útil para diseñar estrategias institucionales y programas de formación que fomenten la integración ética y eficaz de la IA en la enseñanza y el aprendizaje.

Palabras clave: Adopción de tecnología, educación superior, innovación educativa, inteligencia artificial generativa, percepciones.

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Introduction

The integration of Generative Artificial Intelligence (Gen-AI) into higher education is rapidly reshaping the academic landscape. Tools such as ChatGPT, Gemini, and Claude are no longer emerging novelties but are becoming embedded in the daily practices of both students and faculty. Their growing presence has sparked a wave of research aimed at understanding the psychological, pedagogical, and ethical dimensions of Gen-AI adoption in university settings.

To date, most empirical studies have focused on either students or faculty in isolation. On one hand, research on university teachers has highlighted the role of perceived usefulness, attitude, and personal innovativeness in shaping their willingness to incorporate Gen-AI into teaching practices (Miranda & Chamorro-Mera, 2025a; Gutiérrez-Leefmans, 2025; Bhaskar et al., 2024; Lu et al., 2024). On the other hand, studies on students have emphasized the influence of perceived risk, social norms, and attitudes toward AI on their intention to use these tools for academic purposes (Yu & Guo, 2023; Abbas et al., 2025).

However, there is a notable gap in the literature regarding comparative analyses that examine how these two key academic stakeholders- teachers and students- perceive Gen-AI within the same institutional context. Such a perspective is essential for fostering a shared understanding of the opportunities and challenges posed by these technologies. By identifying convergences and divergences in how both groups evaluate the usefulness, risks, ease of use, and institutional support for Gen-AI, universities can design more coherent policies, targeted training programs, and pedagogical strategies that align with the needs and expectations of their academic communities.

This article addresses that gap by presenting a comparative analysis of two surveys conducted at the University of Extremadura (Spain), one targeting faculty and the other students. Using a set of shared indicators, the study explores statistically significant differences in their perceptions of Gen-AI, offering insights into how these tools are being received across the academic spectrum and what this means for their ethical and effective integration into higher education.

This study contributes to the academic literature by offering a comparative perspective that is rarely addressed: the simultaneous analysis of faculty and student perceptions of generative AI within the same institutional context. Unlike previous research grounded in specific theoretical models, this article adopts a descriptive-comparative approach that allows for a more flexible and context-sensitive exploration of attitudes toward Gen-AI. The article is structured as follows: the next section reviews the relevant literature; this is followed by a detailed explanation of the methodology used; the fourth section presents the results of the comparative analysis; the fifth discusses the implications of the findings; and the final sections offer conclusions, acknowledge limitations, and suggest directions for future research.

Literature Review

The integration of Gen-AI into higher education has sparked a growing body of research exploring its pedagogical, ethical, and technological implications. While early studies focused on the capabilities of large language models (LLMs) such as ChatGPT, more recent work has shifted toward understanding the psychological and contextual factors that shape adoption among different academic stakeholders.

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Recent studies have begun to explore not only the drivers of Gen-AI adoption but also its unintended consequences, particularly among students. Abbas et al. (2025) conducted a time-lagged study across six universities in Pakistan, revealing that students with high innovation consciousness are more likely to use ChatGPT, while those with a high need for cognition do not necessarily rely on it. Importantly, their findings suggest that frequent use of Gen-AI tools is positively associated with AI addiction and increased tolerance for academic dishonesty. These results underscore the need for institutions to promote ethical awareness and critical engagement with AI tools, especially in contexts where digital literacy and academic integrity norms vary widely (Abbas et al., 2025)

Complementing this, Batista et al. (2024) conducted a systematic literature review of 37 empirical studies on Gen-AI in higher education, identifying three dominant themes: application of Gen-AI technologies, stakeholder perceptions, and specific use cases. Their review highlights both the versatility of Gen-AI and the challenges it poses, including assessment integrity, institutional readiness, and the need for pedagogical adaptation (Batista et al., 2024). Other systematic reviews highlight both opportunities and risks of Gen-AI adoption in higher education (Salas-Pilco & Yang, 2022; González Torres et al., 2025). Similarly, Jingwei He et al. (2024) conducted a large-scale survey at the Hong Kong University of Science and Technology, revealing that students' adoption of Gen-AI tools is influenced by perceived usefulness, peer influence, and prior experience with AI technologies. Together, these studies underscore the need for universities to promote ethical awareness, critical engagement, and context-sensitive strategies for Gen-AI integration.

Research on students has emphasized a broader range of psychological and social variables. While perceived usefulness and attitude remain central to adoption (Yilmaz et al., 2023; Soliman et al., 2024; Ríos-Hernández Mateus et al., 2024), students' decisions are also shaped by perceived risk, subjective norms, and their attitudes toward the future of AI (Abbas et al., 2025; Ivanov et al., 2024).

Students often adopt Gen-AI tools for practical purposes such as summarizing texts, generating ideas, or improving writing (Shahzad et al., 2024; Shevel et al., 2025). However, their use is frequently self-directed, with limited formal training and ethical guidance. This raises concerns about misinformation, plagiarism, and the lack of critical engagement with AI-generated content (Shahzad et al., 2024).

Moreover, students appear to be more sensitive to social influence, particularly from peers and instructors. The perception that Gen-AI use is normalized or encouraged within their academic environment can significantly shape their attitudes and intentions (Hamamra et al., 2024).

Research on Gen-AI adoption in higher education has frequently drawn on established theoretical frameworks such as the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB). While these models have been applied to both students and faculty, studies focusing on lecturers often highlight attitude and perceived usefulness as the most influential predictors of intention to use Gen-AI in teaching contexts (Miranda & Chamorro-Mera, 2025b; Bhaskar et al., 2024; Lu et al., 2024). Faculty members are more likely to adopt these tools when they perceive them as enhancing productivity, supporting innovation, or facilitating personalized instruction.

Other factors such as perceived ease of use, personal innovativeness, and

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self-efficacy have shown more modest effects. Interestingly, subjective norms- the perceived expectations of colleagues, students, or institutional leadership- have not consistently emerged as significant predictors in Western academic contexts, suggesting that faculty decisions may be more autonomous and less socially driven (Strzelecki et al., 2024).

Despite the generally positive attitudes toward Gen-AI, concerns persist regarding ethical risks, including academic dishonesty, overreliance on automation, and the erosion of critical thinking. These concerns highlight the need for institutional policies that promote responsible and informed use of AI in teaching.

Despite the growing interest in Gen-AI adoption, few studies have examined how faculty and students perceive these tools within the same institutional context. This gap is particularly relevant given that effective and ethical integration of Gen-AI in higher education requires alignment between teaching practices and learning behaviours.

An exception is the study by Ivanov et al. (2024), which analysed both lecturers and students using the Theory of Planned Behaviour. However, their data came from multiple universities and countries, focusing only on actual users, whereas our study examines users and non-users within a single institutional context.

A comparative approach can reveal whether both groups share similar expectations, concerns, and levels of preparedness- or whether there are significant mismatches that could hinder pedagogical coherence. Understanding these dynamics is essential for designing institutional strategies that are inclusive, context-sensitive, and responsive to the needs of all academic actors.

Unlike previous studies that applied structural models based on constructs such as perceived usefulness, attitude, or subjective norms (e.g., TAM or TPB), the present research adopts a descriptive-comparative approach. Rather than testing theoretical relationships, this study focuses on analysing individual survey items that reflect perceptions, attitudes, and experiences related to the use of Generative AI tools in academic contexts. These items were inspired by validated constructs used in earlier research but are treated here as standalone indicators to explore differences between faculty and student responses. This approach allows for a more flexible and context-sensitive examination of how Gen-AI is perceived across academic roles, without the constraints of a predefined theoretical model.

Methodology

This study adopts a descriptive and comparative approach to explore how university faculty and students perceive the use of Gen-AI tools in academic contexts. The data analysed in this article were collected through two online surveys conducted during the 2024–2025 academic year at the University of Extremadura (Spain). The first survey was completed by 61 faculty members from various academic disciplines within the university. The second survey involved 150 undergraduate and master's students. Participation in both surveys was voluntary and anonymous.

While the study offers valuable comparative insights, certain methodological limitations regarding sample size and representativeness should be acknowledged. The faculty sample (n=61), although sufficient for conducting basic statistical analyses such as independent samples t-tests, is relatively small compared to the overall teaching staff at the University of Extremadura. This may limit the generalizability of the findings, particularly across underrepresented academic

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disciplines. Furthermore, participation in both surveys was voluntary and anonymous, introducing the possibility of self-selection bias. It is likely that respondents had a greater interest in or familiarity with generative AI technologies, which could have influenced their responses. As such, the results should be interpreted with caution, recognizing that they reflect the views of a self-selected group rather than a fully representative cross-section of the university community.

The questionnaires included 16 items grouped into five dimensions that reflect key constructs discussed in the literature: (1) Ethical perceptions (e.g., ethical use of Gen-AI, concern for academic integrity), which assess awareness of responsible practices and potential risks; (2) Perceived usefulness (e.g., productivity and quality with Gen-AI, improvement in academic performance, technical problem-solving, adaptation and future readiness), capturing beliefs about the practical benefits of Gen-AI in academic tasks; (3) Ease of use and integration (e.g., ease of use of Gen-AI, ability to integrate Gen-AI), which measure perceived simplicity and confidence in incorporating these tools into workflows; (4) Institutional and social support (e.g., institutional support for Gen-AI, influence of admired individuals), reflecting the role of formal policies and informal norms; and (5) Willingness and attitudes toward adoption (e.g., willingness to use Gen-AI, recommendation of Gen-AI, willingness to learn about Gen-AI, willingness to pay for Gen-AI, confidence in Gen-AI results, accuracy of Gen-AI information), which indicate openness to adoption and trust in outputs.

Each item was measured on a 5-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). This structure ensures alignment with theoretical constructs such as perceived usefulness, ease of use, and social influence, while allowing for a nuanced comparison between faculty and student perceptions.

The analysis focused on descriptive statistics and independent samples t-tests to identify statistically significant differences between faculty and student responses. The independent samples t-test was used to compare the means of two independent groups (faculty and students) for each survey item, under the assumptions of normal distribution and homogeneity of variances. This test evaluates whether the observed differences in group means are statistically significant or likely due to random variation.

In addition to reporting descriptive statistics and p-values from independent samples t-tests, this study also includes Cohen’s d effect sizes to assess the magnitude of differences between faculty and student responses. Cohen’s d is a widely used metric in educational and psychological research that quantifies the standardized difference between two means, offering insight into the practical significance of the results beyond statistical significance alone.

For items showing significant differences ($p < 0.05$), the results were further illustrated using kernel density estimation (KDE) plots to visualize the distribution of responses across groups. These plots provide a smoothed representation of the response distributions, allowing for a clearer comparison of patterns between faculty and students. This methodological approach enables a nuanced understanding of how Gen-AI is perceived across academic roles, without relying on a predefined theoretical framework.

Results

The table 1 presents a summary of the mean scores for faculty and students across

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various survey items related to their perceptions of Gen-AI. The table includes the results of independent samples t-tests conducted to determine whether the observed differences between the two groups are statistically significant. This comparative overview highlights key areas of divergence and convergence in attitudes toward Gen-AI, serving as a quantitative foundation for the subsequent visual and interpretive analysis.

To complement the statistical significance analysis, table 1 includes Cohen's d effect sizes for each survey item. While p-values indicate whether differences between faculty and student responses are statistically significant, Cohen's d provides a standardized measure of the magnitude of those differences. This addition allows for a clearer interpretation of the practical relevance of the observed gaps in perception.

Table 1.
T-test Results: Professors vs. Students on Gen-AI Perceptions

Item (Variable)	Mean Professors	Mean Students	p-value	Cohen´s d effect
Productivity and quality with Gen-AI	3.098	3.927	0.0000*	0.923
Recommendation of Gen-AI	3.311	3.993	0.0000*	0.732
Willingness to use Gen-AI	3.508	4.073	0.0001*	0.615
Ease of use of Gen-AI	3.656	4.047	0.0021*	0.498
Influence of admired individuals	2.590	2.973	0.0032*	0.429
Institutional support for Gen-AI	2.672	3.013	0.0125**	0.363
Ability to integrate Gen-AI	3.525	3.827	0.0330**	0.334
Confidence in Gen-AI results	2.803	3.073	0.0443**	0.314
Accuracy of Gen-AI information	2.754	3.000	0.0558	0.303
Technical problem-solving	3.262	3.407	0.3272	0.149
Improvement in academic performance	3.262	3.347	0.5584	0.087
Ethical use of Gen-AI	3.525	3.593	0.6269	0.073
Willingness to learn about Gen-AI	4.049	3.967	0.5706	−0.088
Willingness to pay for Gen-AI	2.328	2.207	0.4876	−0.104
Concern for academic integrity	3.508	3.387	0.4774	−0.109
Adaptation and future readiness	3.377	3.153	0.1158	−0.231

*Note: * p < 0.01; ** p < 0.05*

The comparative analysis between faculty and students reveals a consistent pattern of divergence in their perceptions of generative AI, particularly in areas related to trust, usability, and integration into academic practices. Statistically significant differences across several items suggest that students generally exhibit greater enthusiasm and confidence toward these tools.

To begin with, students reported significantly higher confidence in the results generated by Gen-AI tools (p = 0.0443), indicating a stronger belief in their reliability (see figure 1). This difference may stem from more frequent use or a lower awareness of potential limitations.

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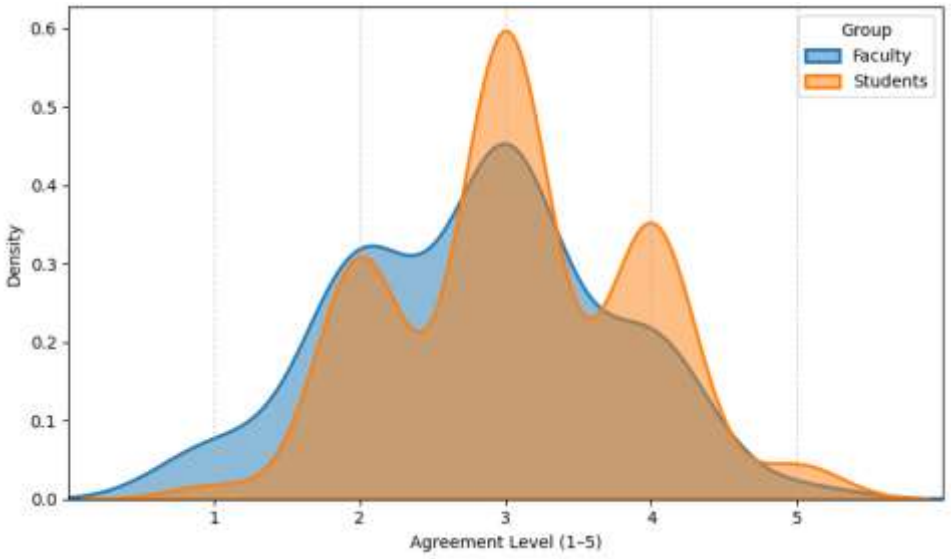


Figure 1. Confidence in Gen-AI.

Although the difference in perceived accuracy did not reach statistical significance ($p = 0.0558$), the trend also favoured students, reinforcing their more optimistic stance.

This greater trust is further reflected in students' markedly higher willingness to use Gen-AI (mean = 4.073 vs. 3.508; $p = 0.0001$) and to recommend it to others (mean = 3.993 vs. 3.311; $p < 0.0001$). These findings suggest that students not only accept Gen-AI more readily but also act as informal advocates for its adoption within academic settings.

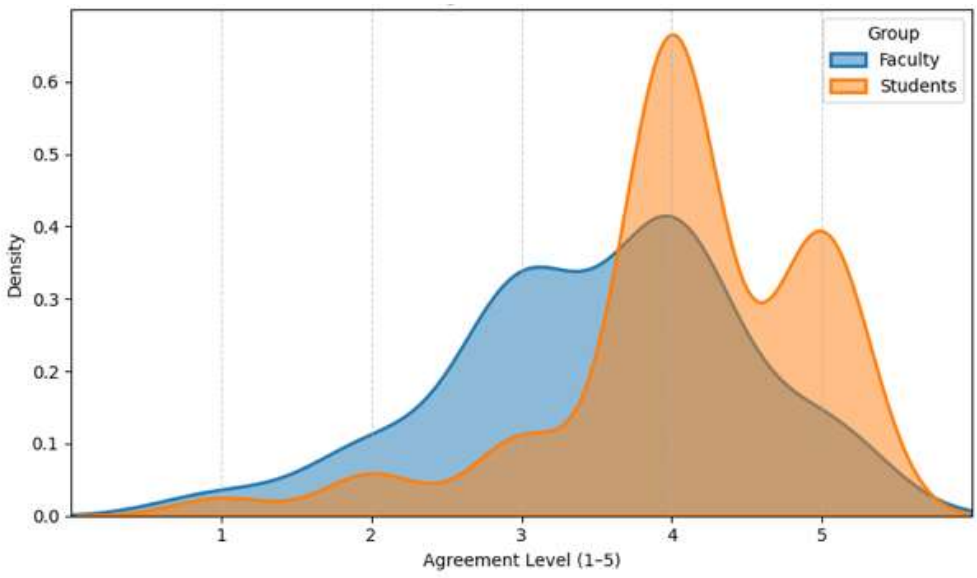


Figure 2. Willingness to use Gen-AI

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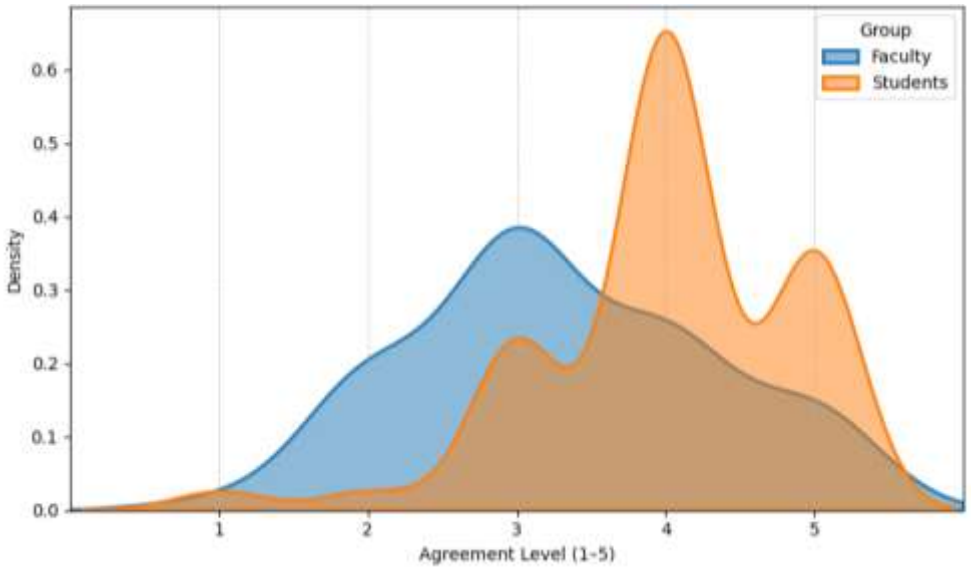


Figure 3. Recommendation of Gen-AI

In line with this favourable attitude (see figure 4), students perceive Gen-AI as more beneficial for enhancing productivity and academic quality (mean = 3.927 vs. 3.098; $p < 0.0001$). This perception is supported by their higher ratings of ease of use ($p = 0.0021$) and greater confidence in their ability to integrate these tools into academic tasks ($p = 0.033$) (see figures 5 & 6). Taken together, these results point to a generational or experiential divide in how Gen-AI is evaluated in terms of practical utility.

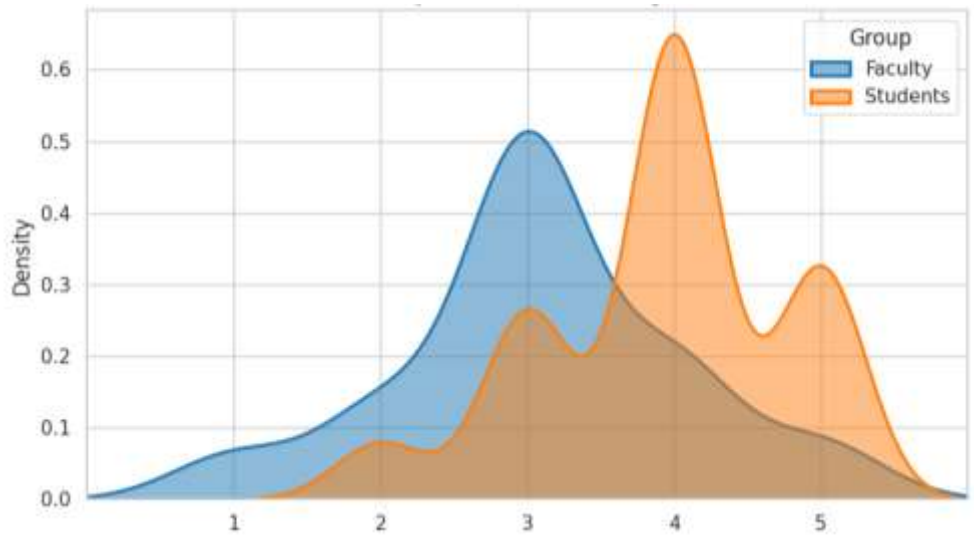


Figure 4. Productivity and quality with Gen-AI

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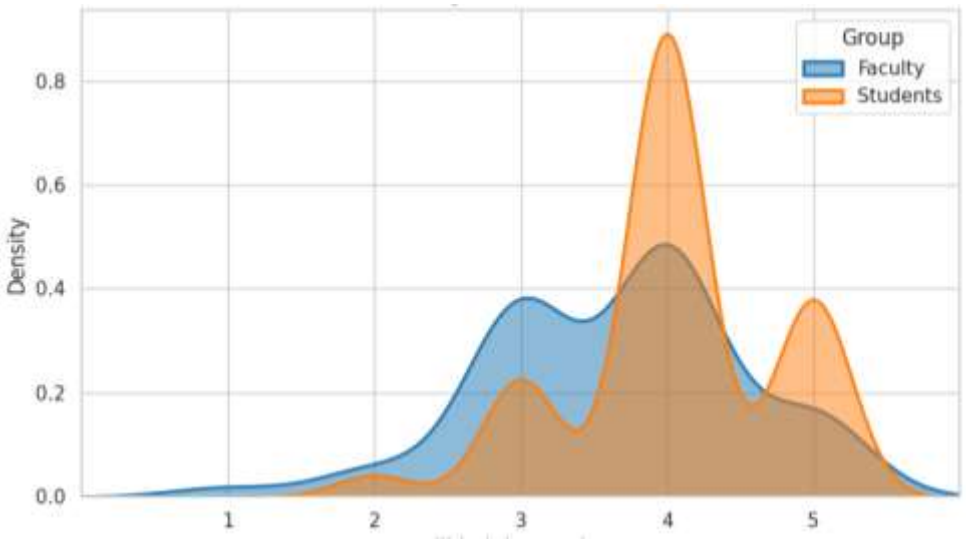


Figure 5. Ease of use of Gen-AI

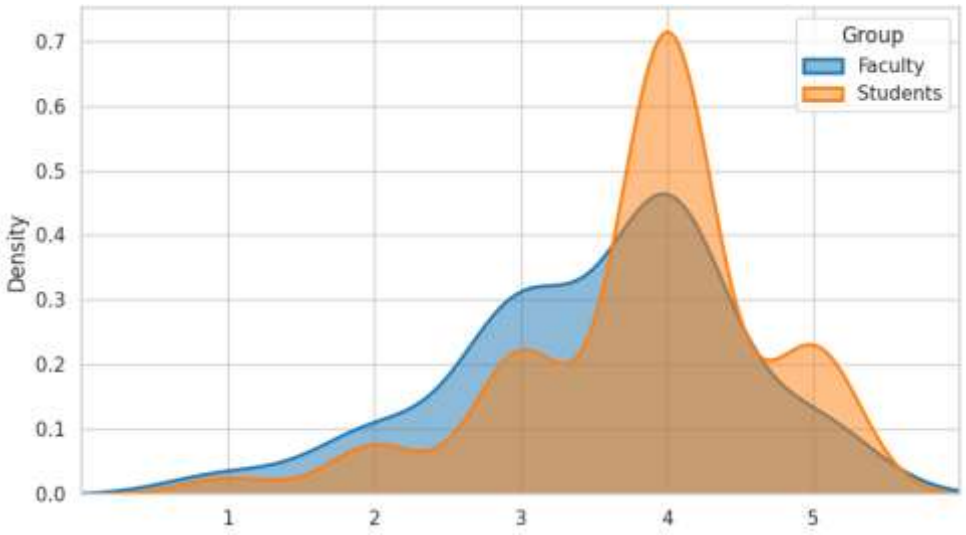


Figure 6. Ability to integrate Gen-AI

Moreover, students reported higher perceptions of institutional support (see figure 7) ($p = 0.0125$) and were more influenced by admired individuals ($p = 0.0032$), suggesting that both formal and informal cues play a stronger role in shaping their attitudes (see figures 7 & 8). In contrast, faculty appear to rely more on personal judgment and professional norms, which may explain their more cautious stance.

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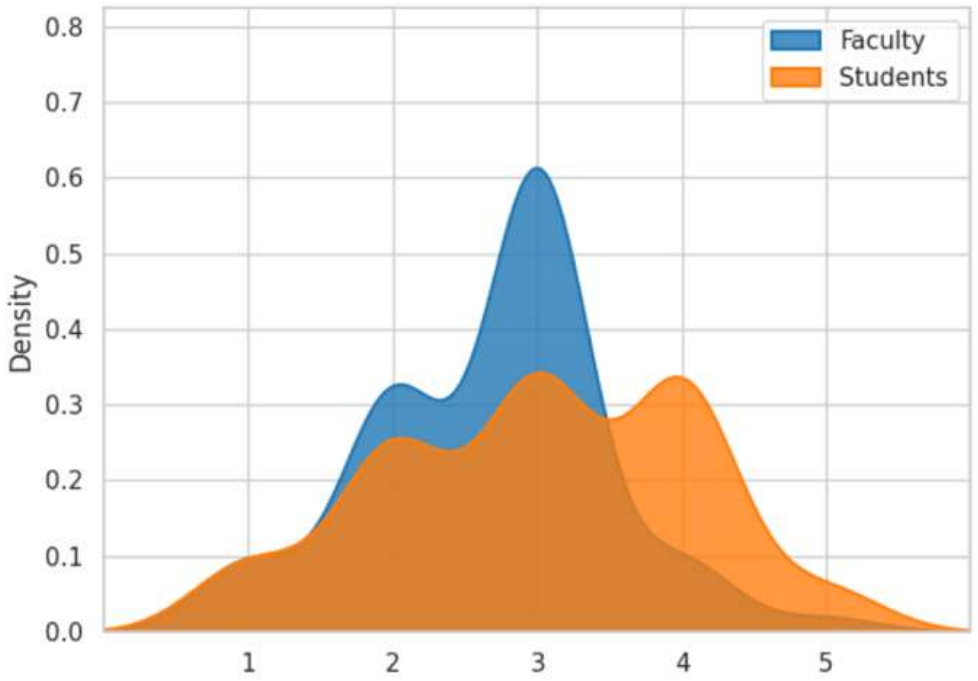


Figure 7. Institutional support for Gen-AI

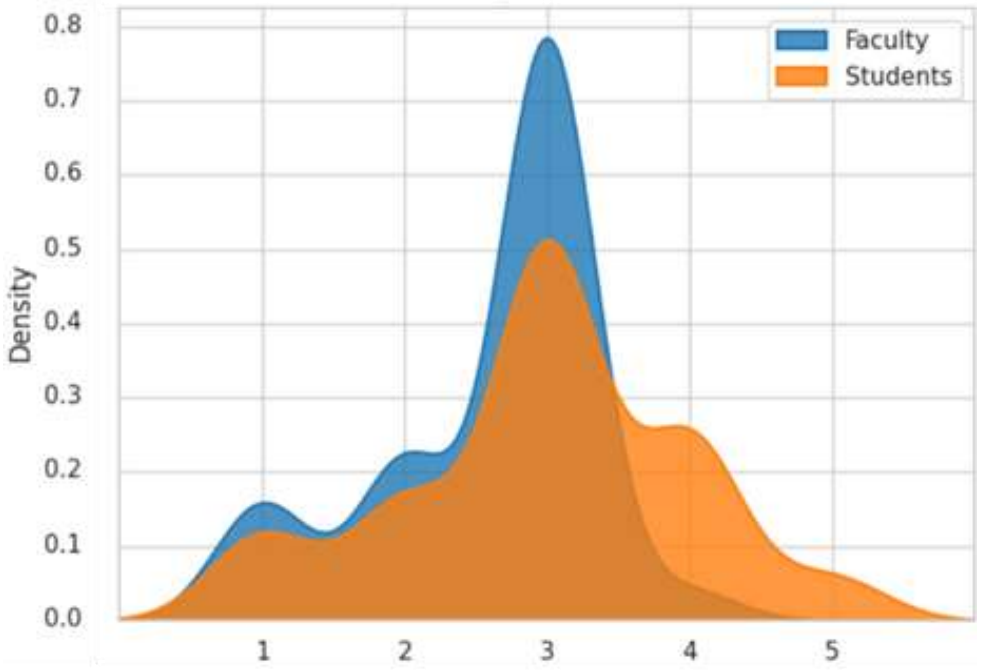


Figure 8. Influence of admired individuals

Finally, although several items did not show statistically significant differences, they still offer relevant insights. Both groups expressed moderate agreement regarding the ethical use of Gen-AI (professors: 3.525; students: 3.593) and concerns about academic integrity (professors: 3.508; students: 3.387), indicating a shared awareness of potential risks. Similarly, both faculty and students showed strong

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interest in learning more about Gen-AI (professors: 4.049; students: 3.967), while their willingness to pay for such tools remained low (professors: 2.328; students: 2.207)—suggesting that, despite high interest, concerns about value or accessibility persist. No significant differences were observed in perceptions of Gen-AI's impact on academic performance (professors: 3.262; students: 3.347), technical problem-solving (professors: 3.262; students: 3.407), or future readiness (professors: 3.377; students: 3.153), although faculty reported slightly higher scores in the latter, possibly reflecting their role in institutional planning.

Discussion

The comparative analysis between faculty and students reveals a consistent divergence in their perceptions of generative AI. Students, often digital natives, display greater confidence and enthusiasm, integrating these tools into their academic routines for tasks such as summarization, idea generation, and writing support. Faculty, by contrast, adopt a more cautious stance, shaped by concerns about reliability, ethical risks, and pedagogical alignment. In practice, this means that students tend to adopt Gen-AI autonomously, while faculty require structured institutional support and clear ethical frameworks to embed these tools responsibly in teaching.

These findings both confirm and nuance previous research. Studies such as He et al. (2024) and Yilmaz et al. (2023) highlight students' perception of usefulness and ease of use, which our results reinforce. Faculty concerns mirror those reported by Kim et al. (2025) and Batista et al. (2024), emphasizing ethical risks and the need for pedagogical adaptation. However, our study contributes a novel perspective by examining both groups within the same institutional context, revealing the coexistence of enthusiasm and skepticism in a shared environment. This contrast suggests that institutional strategies must adapt global recommendations to local dynamics, ensuring coherence between teaching practices and learning behaviours.

A critical reflection on the methodology highlights potential biases. Voluntary participation may have attracted respondents already interested in Gen-AI, and the relatively small faculty sample limits representativeness across disciplines. Institutional culture and disciplinary traditions may also have shaped responses, meaning that results are partly contingent on local conditions. Beyond statistical significance, the reported effect sizes provide practical meaning: large effects, such as productivity (d = 0.923), indicate substantial gaps with immediate implications for policy, while medium and small effects highlight areas where differences exist but may be less impactful in practice. This differentiation underscores the importance of prioritizing institutional strategies around the most consequential divergences.

The results can also be interpreted through theoretical frameworks. Within the Technology Acceptance Model, students score higher on perceived usefulness and ease of use, while faculty responses reflect stronger attitudes and ethical concerns. As Parga García (2023) points out, it is necessary to educate with AI with a critical, ethical, and humanistic vision. The Theory of Planned Behaviour explains students' sensitivity to social influence, whereas faculty decisions appear more autonomous. Digital literacy perspectives further clarify the divide: students demonstrate functional literacy but limited critical literacy, while faculty emphasize critical evaluation. Together, these insights underline the need to foster both functional and critical AI literacy, tailoring support to the distinct roles of students and faculty.

From a practical perspective, these findings suggest that universities should invest

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in differentiated strategies. For faculty, training should focus not only on technical proficiency but also on pedagogical models and ethical frameworks (Sánchez-Trujillo et al., 2025). For students, embedding Gen-AI literacy into curricula (as suggested by Sánchez-Trujillo et al., 2025) and promoting critical engagement with AI-generated content are essential. Institutional policies must bridge the perceptual gap, ensuring that enthusiasm among students is matched by faculty readiness and pedagogical coherence.

Finally, future research should expand the scope by including larger and more diverse samples, conducting longitudinal studies to track evolving perceptions, and incorporating qualitative methods such as interviews or focus groups to capture the reasoning behind attitudes. Such approaches would deepen understanding of how generative AI reshapes higher education and provide more robust guidance for institutional strategies.

Conclusions

Practical implications

The comparative analysis between faculty and students at the University of Extremadura reveals a complex and nuanced landscape of perceptions regarding the integration of Gen-AI tools in higher education. These findings align with and extend recent literature that underscores both the promise and the ambivalence surrounding Gen-AI adoption in academic contexts (Yilmaz et al., 2023; Ivanov et al., 2024; Batista et al., 2024).

One of the most consistent patterns observed is the greater enthusiasm and optimism among students. They report significantly higher levels of confidence in Gen-AI outputs, greater perceived productivity gains, and a stronger willingness to use and recommend these tools. These results are consistent with recent global surveys indicating that over 80% of students are already using Gen-AI tools regularly, often without formal institutional guidance (Campbell Academic Technology Services, 2025). This widespread adoption may explain their higher comfort levels and perceived benefits, particularly in tasks such as summarization, ideation, and writing support.

In contrast, faculty responses reflect a more cautious and critical stance, particularly regarding the reliability and ethical implications of Gen-AI. Kim et al. (2025) and Fernández-Miranda et al. (2024) found that while both students and instructors are experimenting with Gen-AI tools, faculty express more concern about ethical risks and the pedagogical value of these technologies. These concerns include the erosion of critical thinking, the potential for academic dishonesty, and the lack of alignment between Gen-AI's commercial logic and educational goals.

The statistically significant differences in perceived ease of use and ability to integrate Gen-AI further highlight a generational or experiential divide. Students, often digital natives, find these tools more intuitive and seamlessly incorporable into their workflows. Faculty, on the other hand, may face steeper learning curves or institutional constraints that hinder integration. This echoes findings from Batista et al. (2024), who emphasize the need for targeted professional development and institutional strategies that support faculty in navigating the pedagogical and ethical complexities of Gen-AI.

Beyond the statistical differences, the findings also invite reflection on the pedagogical implications of Gen-AI integration. Curriculum design and instructional

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strategies may need to evolve to better align with students' growing familiarity and reliance on these tools. This could include embedding Gen-AI literacy into course objectives, promoting critical engagement with AI-generated content, and training students to use these technologies ethically and effectively.

Additionally, the observed divergences may be partially explained by generational or cultural factors. Students, often digital natives, may approach Gen-AI with greater openness and confidence, while faculty- shaped by different technological and educational paradigms- may exhibit more caution. Future research should explore how age, disciplinary background, and cultural context influence perceptions and adoption patterns, as these variables could inform more tailored and inclusive institutional strategies.

Another notable finding is the greater influence of admired individuals on students' attitudes toward Gen-AI. This suggests that peer norms and role models play a significant role in shaping student behaviour, a dynamic well-documented in technology adoption literature. Faculty, by contrast, appear to rely more on professional judgment and institutional policy, reinforcing the importance of leadership and policy clarity in shaping faculty engagement.

The perceived lack of institutional support, particularly among faculty, raises important questions about how universities are communicating and operationalizing their AI strategies. While students may interpret access to tools as implicit support, faculty may expect more structured guidance, training, and ethical frameworks. This disconnect underscores the need for clear, inclusive, and role-sensitive institutional policies that address the distinct needs and expectations of both groups.

From a managerial perspective, these findings offer several actionable insights. First, institutions must address the perceptual and experiential gap between students and faculty. While students exhibit high levels of enthusiasm, confidence, and perceived utility regarding Gen-AI tools, faculty responses are more cautious and reflect concerns about reliability, ethical risks, and pedagogical alignment. This divergence suggests that institutions must invest in tailored training and support structures for faculty, not only focusing on technical proficiency but also on pedagogical strategies and ethical frameworks that enable meaningful and responsible integration of Gen-AI into teaching practices.

Second, the high levels of student engagement with Gen-AI present an opportunity to promote critical and reflective use of these tools. Institutions should consider embedding Gen-AI literacy into the curriculum, encouraging students to evaluate AI-generated content thoughtfully and ethically. Leveraging student enthusiasm through peer-led initiatives or ambassador programs could further enhance responsible adoption.

Third, the strategic role of leadership and role modelling cannot be overstated. Faculty champions and institutional leaders who demonstrate thoughtful and effective uses of Gen-AI can help shape a culture of responsible innovation. Their visibility and example can bridge the gap between policy and practice, fostering trust and engagement across the academic community.

Finally, universities must articulate their stance on Gen-AI use, define acceptable practices, and provide accessible resources that support both innovation and academic integrity. These policies should be co-developed with input from diverse academic stakeholders to ensure they are context-sensitive and widely accepted.

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As recent studies suggest (Kim et al., 2025), demographic and disciplinary diversity must be considered when designing these strategies, as perceptions and usage patterns vary significantly across groups.

These recommendations are directly supported by the statistical evidence reported in this study. The large effect size observed in perceptions of productivity and quality (d=0.923) underscores the urgency of embedding Gen-AI literacy into curricula, while medium effects such as willingness to use (d=0.615) highlight the need for faculty training programs. Smaller effects, including confidence in Gen-AI results (d= 0.314), suggest areas where differences are less pronounced but should be monitored over time. By linking institutional actions to the magnitude of observed effects, universities can prioritize strategies that address the most consequential gaps while remaining attentive to emerging challenges.

The successful integration of Gen-AI in higher education requires more than access to technology. It demands coordinated efforts in training, policy, communication, and leadership that recognize the distinct needs and perspectives of both students and faculty, while fostering a shared vision of ethical and effective AI use in academic life.

General conclusions

This study provides a comparative perspective on how faculty and students perceive the integration of Gen-AI tools in higher education. Drawing on survey data from a Spanish university, the analysis reveals significant differences in eight key areas: confidence in Gen-AI results, ability to integrate these tools, ease of use, institutional support, influence of admired individuals, willingness to use and recommend Gen-AI, and perceived impact on productivity and quality. Students consistently report higher levels of confidence, greater perceived usability, and stronger willingness to adopt and advocate for Gen-AI, while faculty, although generally open to innovation, express more caution, particularly regarding reliability and ethical implications.

These findings underscore the importance of role-specific strategies for Gen-AI integration. While students appear ready to embrace these tools, often driven by peer influence and perceived utility, faculty may require more structured support, training, and policy clarity to align Gen-AI use with pedagogical goals and academic standards. The divergence in perceptions also highlights the need for institutional coherence: successful and ethical integration of Gen-AI depends not only on technological access but also on shared understanding, mutual trust, and inclusive governance.

However, this study is not without limitations. First, the sample is limited to a single institution, which may constrain the generalizability of the findings. Cultural, disciplinary, and institutional differences across universities could yield different patterns of perception and adoption. Second, the study relies on self-reported data, which may be subject to social desirability bias or limited awareness of Gen-AI capabilities. Third, the cross-sectional design captures perceptions at a specific moment in time, without accounting for how attitudes may evolve as Gen-AI tools become more embedded in academic routines.

It is also important to acknowledge the relatively small faculty sample, which, although adequate for basic statistical tests, may limit the generalizability of the findings across all academic disciplines. This constraint, combined with the voluntary nature of participation, suggests that the results should be interpreted with caution.

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These methodological constraints may have influenced the results in specific ways. The voluntary nature of participation likely attracted respondents with greater interest in Gen-AI, which could partly explain the high levels of enthusiasm reported by students. Similarly, the relatively small faculty sample may have amplified the cautious stance observed, as certain disciplines or perspectives may be underrepresented. The single-institution context also means that perceptions are shaped by local policies, resources, and cultural factors, which may not reflect broader academic environments. For these reasons, the findings should be interpreted as indicative rather than universally generalizable, and institutional strategies derived from them must be adapted carefully to other contexts.

Future research should build directly on the divergences observed in this study. The strong enthusiasm among students calls for longitudinal studies that track whether early adoption translates into sustained academic benefits or risks of overreliance. The cautious stance of faculty highlights the need for qualitative approaches—such as interviews or focus groups—to explore the underlying pedagogical and ethical concerns that survey data cannot fully capture. The influence of admired individuals on students' attitudes suggests examining the role of peer norms and role models in shaping responsible AI use, while the perceived lack of institutional support points to comparative studies across universities to identify how different policy frameworks affect adoption. Finally, expanding the scope to include diverse disciplines and international contexts would clarify whether the generational and cultural factors identified here are universal or context-specific.

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Original Article

Creative pedagogical methods for fostering tolerance and empathy in music education: A comparative study of vocalists and instrumentalists

Métodos pedagógicos creativos para fomentar la tolerancia y la empatía en la educación musical: un estudio comparativo entre vocalistas e instrumentistas

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Abstract

This study aims to evaluate the effectiveness of creative teaching methods in developing empathy and tolerance in music students. Methods included functional analysis, analytical-synthetic approaches, the Mayer–Salovey–Caruso Emotional Intelligence test, the Cultural Intelligence Scale, Likert scales, the Wilcoxon criterion, and the Cohen coefficient. Findings indicate that tolerance supports the perception of musical styles, high-quality group performance, and intercultural and professional ethical competence, while empathy enhances emotional perception and expressive performance. Creative methods such as interactive music platforms, intercultural techniques, musical improvisation, game-based learning, musical discussions, and empathic reconstruction proved effective. Group No. 1 (vocal) showed high group performance and cognitive tolerance development, while Group No. 2 (instrumental) excelled in individual performance and metacognitive tolerance. The study highlights the practical significance of creative approaches for cultivating empathy and tolerance in musician training.

Keywords: intercultural competence, musical skills, non-standard teaching approaches, professional competence, psychological readiness.

Resumen

Este estudio tiene como objetivo evaluar la efectividad de los métodos de enseñanza creativos en el desarrollo de la empatía y la tolerancia en estudiantes de música. Los métodos utilizados incluyeron análisis funcional, enfoques analítico-sintéticos, la prueba de Inteligencia Emocional Mayer–Salovey–Caruso, la Escala de Inteligencia Cultural, escalas Likert, el criterio de Wilcoxon y el coeficiente de Cohen. Los resultados indican que la tolerancia favorece la percepción de estilos musicales, el desempeño grupal de alta calidad y la competencia ética intercultural y profesional, mientras que la empatía mejora la percepción emocional y la interpretación expresiva. Métodos creativos como plataformas musicales interactivas, técnicas interculturales, improvisación musical, aprendizaje basado en juegos, discusiones musicales y reconstrucción empática demostraron ser efectivos. El Grupo No. 1 (vocal) destacó en desempeño grupal y desarrollo cognitivo de la tolerancia, mientras que el Grupo No. 2 (instrumental) sobresalió en desempeño individual y tolerancia metacognitiva. El estudio resalta la importancia práctica de los enfoques creativos para cultivar empatía y tolerancia en la formación de músicos.

Palabras clave: competencia intercultural, competencias musicales, enfoques de enseñanza no estándar, competencia profesional, preparación psicológica.

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Introduction

The transformation of the classical education system is focused on improving students' ability to memorize information and developing their initiative. Acquiring these skills allows students to perceive educational materials through analysis, solve non-standard professional problems, and develop tolerance and empathy. Tolerance and empathy skills are necessary for successful learning during group work and interaction with the teacher. These skills also influence the perception of the emotionality and depth of music and its cultural characteristics. Rethinking teaching strategies influences the growth of professional skills and adherence to social ethics, as confirmed by recent studies (Cronenberg et al., 2023; Goffi-Fynn, 2024).

Creative teaching methods, which are advanced methods of developing professional skills and actively and experimentally engaging students, influence the development of creative thinking and imagination (Chen, 2024; de Abreu, 2025; Humberstone et al., 2024). In the training of musicians, this process contributes to the implementation of creative projects and the emotional perception of music, relying on cognitive skills. The choice of non-standard teaching methods influences students' choice of new methods for reproducing musical ideas.

Despite the advantages of creative methods for teaching and developing tolerance and empathy in students, this approach also has a negative impact (Brandel et al., 2024; Sitanggang et al., 2025). The negative effect is reflected in the workload of students as a result of searching for approaches to constant self-expression. During group interaction, creative approaches can lead to a decrease in tolerance towards students who are more closed and do not show activity when solving creative tasks, which is reflected in a decrease in self-esteem. Reducing the negative impact of creative methods and gradually developing tolerance and empathy in the learning process is possible by changing the intensity of learning and ensuring that tasks are distributed evenly among all students.

However, the consideration of creative methods for involvement in the educational process is primarily associated with an emphasis on acquiring only specialized skills or exclusively psychological resilience. The relationship between the use of creative methods for assessing the development of tolerance and empathy in the educational process has not been sufficiently researched. The aim of this work is to identify the advantages of creative educational approaches for developing empathy and tolerance skills in students. Research hypothesis: mastering tolerance and empathy in future musicians through creative educational approaches contributes to the improvement of musical skills.

Literature Review

The conceptual basis is based on the praxis philosophy of music education developed by Elliott (2000). Within this approach, music is viewed not as an autonomous aesthetic object, but as an activity immersed in a social and cultural context. Music education is interpreted as a process of active participation in "musical practice" that combines cognitive, emotional, and ethical dimensions. Elliott emphasizes that affect and musical understanding are formed through the experience of collaboration, listening, and reflection. This interpretation allows us to justify the connection between the development of empathy, tolerance, and the quality of musical performance, since musical competence emerges as an integrated characteristic of professional and social interaction.

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The transformation of the educational process is the subject of contemporary scientific research focused on the formation of professional rules of conduct and tolerant attitudes toward other students. The studies indicate the need to develop tolerance and empathy in students to improve their professional skills (Palazzolo, 2024; Zhongsheng, 2025). The need to introduce non-standard teaching approaches that promote change in traditional education and are focused on personal development is discussed in the works of Wan (2023). Wan (2023) notes that the use of non-standard teaching approaches in music education influences the improvement of creative thinking. Creativity skills influence more effective group musical interpretation as a result of adaptation to the performance methods of other musicians (Wan, 2023).

The concept of “musicking” proposed by Small (1998) is of significant theoretical importance. The author expands the understanding of music as a process of interaction in which meaning is created not only during performance, but also in shared listening and communication between participants. The musical experience emerges as a social act that reflects the system of relationships between people, cultures, and values. In this context, tolerance and empathy are not additional psychological qualities, but rather internal conditions for productive “musicking.”

The impact of non-standard teaching strategies on improving tolerance and empathy in professional training is discussed in studies by Davila-Barrio et al. (2023); Corral et al. (2023); Fernández (2024). The development of empathy in the educational process contributes to the social development of students, which is reflected in the quality of musical interpretation in groups. The emphasis on developing empathy contributes to improving the musical experience through joint projects with other students and the exchange of knowledge (Davila-Barrio et al., 2023). A tolerant attitude towards students and the exchange of experience contributes to the understanding of artistic ways of expressing music, which promotes creative performance (Corral et al., 2023). A study by Fernández (2024) indicates that creative methods promote the study of different music, which allows the generation of musical textures to create new sounds for compositions.

Methodological guidelines for the pedagogical implementation of these ideas are contained in Swanwick (2008), where music education is defined as a process of holistic immersion in artistic content. Swanwick emphasizes the importance of balance between technical training, creative interpretation, and personal reflection. The development of musicality is linked to the ability of students to comprehend the structure of a piece, its intonational features, and the cultural context of its creation. Therefore, the formation of empathy and tolerance can be seen as part of a pedagogical strategy aimed at a deep understanding of musical content and the conscious acceptance of different performance positions.

The study by Chang et al. (2022) found that the formation of tolerance and empathy promotes focused learning. Such learning promotes the combination of interdisciplinary approaches, which stimulates original thinking. Author Cain (2023) notes that developed empathy allows for more accurate transmission of experiences through musical works, which influences creative and improvisational self-expression.

A separate segment of scientific works is aimed at fostering empathy and tolerance in future musicians with the help of digital tools (Ruan, 2024; Wen, 2024). In particular, Ruan (2024) notes that professional interactive music programs motivate students to better understand music. The Soft Mozart application promotes comprehensive individual and group music training, which ensures an increase in

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professional competence. Wen (2024) notes that interactive online technologies allow for a change in the approach to learning, which contributes to the formation of tolerance and the solution of professional tasks using creative approaches.

Analysis of scientific works has made it possible to determine the importance of original educational strategies for the holistic formation of students' personalities. The characteristics of tolerance and empathy are considered superficially from a psychological point of view due to the use of non-standard educational practices. Little-studied aspects include the use of optimal original strategies that influence tolerance and empathy in future musicians of various genres (vocalists and instrumentalists).

Methodology

The study used general theoretical and experimental methods. General theoretical methods, which included functional-analytical and analytical-synthetic approaches, helped to determine the need to develop tolerance and empathy in future musicians and to identify creative teaching mechanisms for generating these competencies. Such methodological tools influenced the understanding of the specifics of training, professional practice of musicians, and signs of tolerance and empathy. The theoretical materials obtained were combined to form a holistic view of creative teaching methods. The experimental fragment was made possible by 28 musicians who were divided into two groups. The area of specialization became the basis for the creation of two groups of students. Group No. 1 included 14 students who studied vocal performance (pop and jazz). Group No. 2 included 14 students who acquired skills in playing musical instruments (piano, guitar, saxophone). Future musicians were trained in their second year. The emphasis on second-year students was due to their ability to adapt to the volume of educational materials. The total training period lasted 15 weeks. The research sample was formed on the basis of convenience sampling, as students from one educational institution who were in their second year of study and agreed to participate in the pedagogical experiment were involved. This approach was determined by organizational capabilities and the specifics of the educational process.

Empathy in future musicians before and after training was assessed using the Mayer–Salovey–Caruso Emotional Intelligence Test (further – MSCEIT) (Sambol et al., 2025). The MSCEIT criteria for assessing empathy were the degree to which students assimilated emotions when interacting with other students and in musical works (understanding the idea of a musical work); understanding the emotionality of musical works depending on their complexity (the specifics of musical interpretation depending on the genre, cultural diversity, etc.); the ability to reflect emotional signals (nonverbal communication between students). The Cultural Intelligence Scale (further – CIS) was used to analyze the degree of tolerance in future musicians (Widodo, 2024). The CIS includes cognitive (understanding the characteristics of other musical cultures), motivational (developing student interest), behavioral (responding to external factors), and metacognitive (understanding the characteristics of different music) aspects. Tolerance and empathy on the CIS scale and the MSCEIT methodology were assessed by seven teachers while observing students during the learning process. During the observation, R. Likert's scale was used, which allowed, with the help of 5 points, to set a scale of mastery of tolerance and empathy skills in students (Memmedova & Ertuna, 2024). Students achieving a score of 5 points corresponded to a high level of development. Appendix A provides indicators of the degree of tolerance and empathy for each student. The indicator of musical performance was established using a 10-point scale. Appendix B shows the

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individual indicators for each student. Statistical calculations using Wilcoxon's F criterion (Siegel & Castellan, 1988) were used to compare the indicators of tolerance and emotionality development.

$$W = min\left(\left(\sum_{d_i>0} X_{after,i} - X_{before,i}\right)^{+}, \left(\sum_{d_i<0} X_{after,i} - X_{before,i}\right)^{-}\right), \quad (1)$$

where $X_{before,i}$ – rank value before the student completes the training; $X_{after,i}$ – rank value after the student has completed the training.

A significant difference between student performance before and after the study will be observed when the value $W \leq W_{kr}$ is achieved. Since 14 students participated in each of the two groups, the threshold value of Wilcoxon's criterion was 21.

The comparison of the musical performance abilities of students in groups 1 and 2 using the acquired skills of tolerance and empathy was carried out using the P. Cohen coefficient (Cohen, 1988):

$$d = \frac{\overline{X}_{after} - \overline{X}_{before}}{s_d}, \quad (2)$$

where $\overline{X}_{after}, \overline{X}_{before}$ – averaged values of student performance after and before the use of creative teaching methods ($\overline{X}_{after} - \overline{X}_{before} = \overline{d}$); s_d – standard deviation.

To account for the large size of the effect, it is worth considering that the calculated value should be greater than 0.8; for a medium effect, from 0.5 to 0.8; for a minor effect, less than 0.4.

Results

The educational process should include both the improvement of musical abilities and tolerance and empathy, which are interrelated with creative competence and intelligence. Previous studies have shown that students need to have tolerance and empathy skills in order to perceive the opinions of other students, especially in the process of collaborative work (Powers, 2025; Rastruba et al., 2025). Tolerance and empathy influence the awareness of responsibility for one's own actions and statements, which contributes to a positive atmosphere among students. Other studies focus on the need to develop tolerance and empathy in future musicians (Cholifah, 2024; Behrens, 2025). This has a positive effect on group musical interpretation, allowing musical interpretation methods to be adapted to different musicians. In studies (Canham, 2023; Setiawan et al., 2024), the development of tolerance is associated with an understanding of the importance of reproducing cultural specificity and the composer's intention in musical works. Based on the data from previous scientific works, an idea of the importance of tolerance and empathy skills in future musicians is formed. Figure 1 examines the characteristics of the formation of professional skills in musicians depending on indicators of tolerance and empathy.

Skills of tolerance and empathy broaden individuality in musical performance and promote quality interaction with other students. Thus, a conscious perception of musical works and their connection with national traditions is formed. During performance, this allows for the preservation of constructive technical methods of performance, combining them with cultural characteristics. Collective performance becomes more synchronized and focused on expressiveness, determined by the perception of signals from other group members (glances, gestures) for tempo

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performance. Tolerance skills influence the search for ways to perform well, rather than reflecting one's own stereotypes, which impair the dynamics of performance.

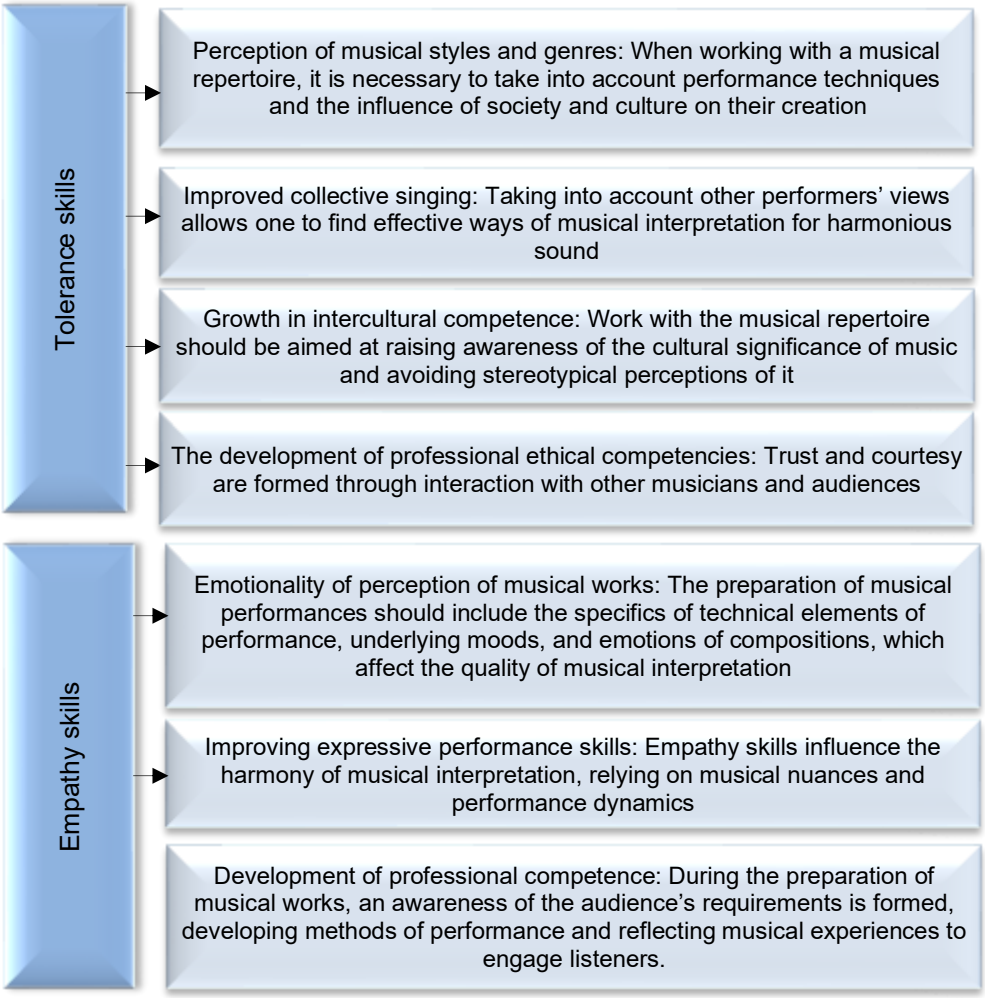


Figure 1. Assessment of the need to develop tolerance and empathy in future musicians.

Source: developed by the authors based on materials (Canham, 2023; Cholifah, 2024; Setiawan et al., 2024; Behrens, 2025; Powers, 2025; Rastruba et al., 2025).

Recent studies have focused on developing tolerance and empathy in students by changing traditional educational strategies (Yao & Li, 2023; Ambrose et al., 2025; Wang, 2025). Their development through non-standard approaches in teaching occurs through student communication, which is reflected in the perception of students' musical improvisations (tolerance) and the establishment of relationships with other performers (empathy). The works Guo et al. (2024); Tan (2025) indicate that it is the creative approach that allows for higher results. The emphasis on student self-expression allows them to value the opinions of others by avoiding a critical approach. Table 1 lists creative methods that can be used in the educational process of future musicians to develop tolerance and empathy.

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Table 1.
Creative teaching methods for developing empathy and tolerance in future musicians

Creative method	Features of use in music education	Specificity of the impact on the development of empathy and tolerance
Using interactive music platforms	Can contribute to the formation of individual and group musical performance skills	Expanding ways of perceiving musical information and alternative ways of interpreting compositions
Intercultural method	A combination of musical works of different styles and genres	Building respect for different musical cultures
Creating musical improvisations	Promote in-depth study of music (individually or in groups) to form an extraordinary sound	Developing emotional sensitivity and respect for other musicians
Game format	Can be used to implement individual musical roles or create competitions between different groups of musicians	Developing emotional experience and accepting other ways of performing
The method of musical discussions	Focused on in-depth understanding of topics	Developing goodwill towards others and the thoughts they reflect
Empathic reconstruction method	Emphasis on developing the emotionality of musical performance	Formation of emotional sensitivity and perception of cultural features of music

Source: developed by the authors based on materials (Yao & Li, 2023; Guo et al., 2024; Ambrose et al., 2025; Wang, 2025)

Creative teaching methods are more focused on students' self-expression, which changes the role of the teacher to that of a mentor who promotes students' self-expression. Interaction with other musicians based on tolerance and empathy skills influences the ability to subtly perceive musical emotions for constructive performance. These skills promote musicians' openness to other cultures, expanding their creative potential.

Ensuring the educational process for 28 musicians involved the use of all the creative approaches listed in Table 1 in the educational process. The sample was taken from 14 vocal students (group No. 1) and 14 instrumental students (group No. 2) who were in their second year of study at. The selection of second-year students was justified by the stability of the educational process and the initial stage of forming the individuality of musical performance and the development of professional ethics. To improve theoretical and practical training, the interactive music platform MusicTrainer 2.0 was used, which allowed students from both groups to focus on methods of vocal and instrumental performance, taking into account intonational and rhythmic features. The Mayer–Salovey–Caruso Emotional Intelligence Test (Sambol et al., 2025) was used to assess the empathy skills of future musicians. The use of the MSCEIT methodology made it possible to assess the level of emotions perceived by students (during interaction with other students and in musical works); understanding of the emotionality of musical works depending on their complexity; the ability to convey emotional signals. Tolerance was assessed using the Cultural Intelligence Scale (Widodo, 2024). In accordance with the methodology, the criteria for assessing tolerance were cognitive, motivational, behavioral, and metacognitive. The assessment of the formed tolerance and empathy was determined in the conditions of a pedagogical

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experiment, which, with the help of the creative methods used, helped to determine the change in these skills using the observation method. The observation process by seven teachers involved assigning scores to students according to the Likert scale, where 5 points corresponded to a high level of manifestation of a particular skill, and 1 point corresponded to a low level. A statistical comparison of the results was obtained using Wilcoxon's criterion, which reflects the ratio of students' results before and after the study when the calculated value (W) exceeds the critical value (W_{crit}). The results of each student before and after the study are presented in Appendix A (Table 2).

Table 2.
Assessment of the level of tolerance and empathy in students of both groups before and after the study

Advanced skills	Group No. 1					Group No. 2				
	To the use of creative approaches, the score	After using creative approaches, the score	IN	IN_{Crete}	r	To the use of creative approaches	After using creative approaches	IN	IN_{Crete}	r
Tolerance skills assessment:										
Cognitive aspect	3	4,6	0,0002	21	<0,001	2,9	4,5	0,0002	21	<0,001
Motivational aspect	3	4,4	0,0001	21	<0,001	2,6	4,4	0,0001	21	<0,001
Behavioral aspect	3,3	4,4	0,0001	21	<0,001	2,7	4,3	0,0001	21	<0,001
Metacognitive aspect	2,6	4,5	0,0003	21	<0,001	2,8	4,8	0,0004	21	<0,001
Empathy skills assessment:										
The level of emotions perceived by students during interactions with other students	2,6	4,8	0,0003	21	<0,001	2,4	4,6	0,0002	21	<0,001
The level of emotions perceived by students in musical works	2,5	4,6	0,0002	21	<0,001	2,1	4,8	0,0004	21	<0,001
Understanding the emotionality of musical pieces depending on their complexity	2,4	4,4	0,0001	21	<0,001	2,0	4,6	0,0002	21	<0,001
Ability to transmit emotional signals	2,2	4,5	0,0002	21	<0,001	1,9	4,5	0,0002	21	<0,001

Source: developed by the authors based on student performance

The assessment of empathy skills among future vocalists and instrumentalists showed improvement, which was reflected in their interaction with other students and in their perception of musical works. After using creative teaching methods, students in group 2 developed empathy skills in interacting with other students (4.8 points) and perceiving emotions in musical works (4.6 points) at almost the same level. Interaction with other students was reflected in the perception of different ways of emotional perception of compositions and reproduction of emotions during group performance. Students in group #1 were better able to develop skills for conveying emotional signals (4.5 points), which allowed them to engage in dialogue with other students during group performances.

The level of tolerance of students was also increased in groups 1 and 2 with the help of creative teaching methods. Students in group No. 1 were able to develop cognitive skills (4.6 points) and metacognitive skills (4.5 points) at the highest level, which allowed them to perceive not only the characteristics of music from other cultures,

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but also to navigate existing differences. The development of motivation (4.4 points) and behavioral skills (4.3 points) in students of group No. 2 was associated with the formation of high-quality performance of songs in interaction with other students, which was reflected in the consideration of the expressiveness of songs, styles, and artistic features. A comparison of the level of empathy and tolerance in future musicians before and after the use of creative teaching approaches using Wilcoxon's criterion showed an improvement in student results.

During the study, it was experimentally established how the development of tolerance and empathy in students affected the quality of musical performance. Attention was paid to the peculiarities of musical interpretation in groups and individually. Grades were given on a 10-point scale by seven teachers who participated in the educational process using creative methods. Thus, scores of 8-10 corresponded to a high level of performance, which included the accuracy of performance technique and emotionality of sound. Scores from 4 to 7 corresponded to an average level, which allowed for up to 4 mistakes in musical performance. To compare the performance of future musicians before and after the use of creative teaching approaches, the P. Cohen coefficient was used. The performance data for all students is presented in Appendix B. The results are shown in Figure 2-3 and Table 3.

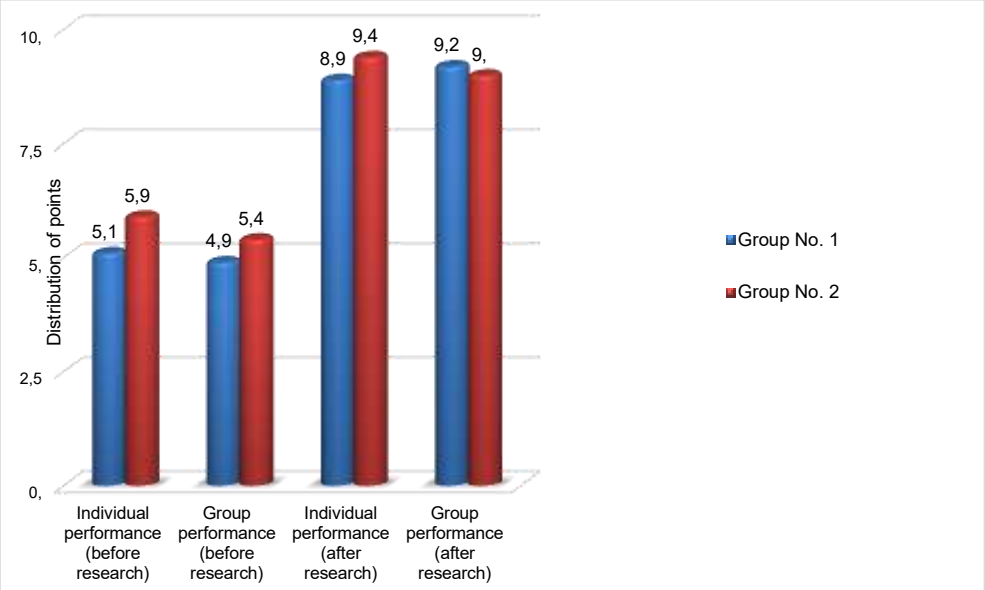


Figure 2. Quality of musical performance by students in groups 1 and 2 before and after training in the study conditions.
Source: developed by the authors.

The highest quality of individual musical performance was observed among students in group No. 2 (9.4 points), which was associated with understanding the content of the works and accepting their style. This influenced the quality of sound modeling, which excluded stereotypical performance depending on the musical style. Students in group No. 1 (9.2 points) showed higher results in group vocal performance, which is associated with the establishment of social connections between students to take into account the emotionality of the performance.

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Table 3.
Comparison of student performance before and after the study within the same group using the Cohen's coefficient

Method of execution	Cohen's coefficient		
	$\overline{d}$	s_d	d
Group No. 1			
Individual execution	3,86	1,62	2,38
Group performance	4,36	1,48	2,95
Group No. 2			
Individual execution	3,5	1,09	3,21
Group performance	3,57	1,69	2,11

Source: developed by the authors based on student performance

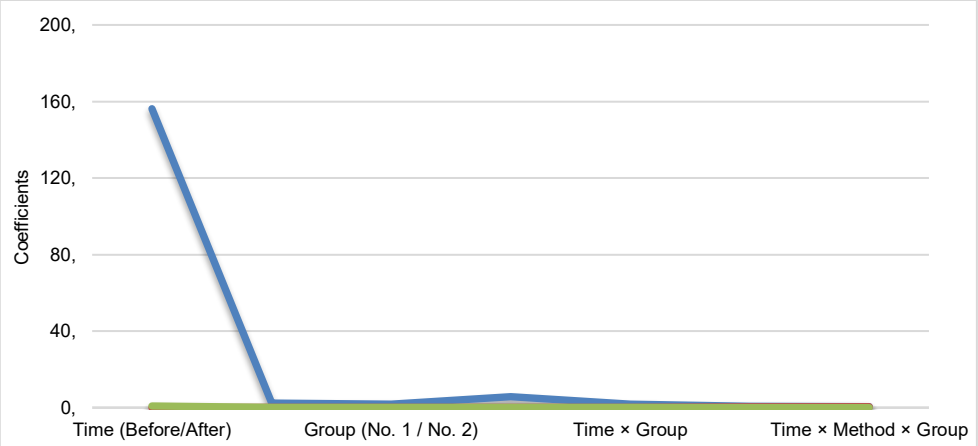


Figure 3. Assessment of the impact of indicators on the quality of musical performance in the context of multifactorial modeling.
Source: developed by the authors.

Based on a three-dimensional multifactorial model, it is evident that the duration of training had the greatest impact on student performance. This is due to the emphasis on developing tolerance and empathy, which allowed for more precise performance of musical works. It was established that the difference between individual and group performance was not significant. Similar data were obtained between vocal and instrumental groups of students. The interaction of other indicators is statistically insignificant.

Discussion

The results confirm the positive impact of creative teaching methods on the development of empathy, tolerance, and musical skills. However, the main point is not the increase in indicators themselves, but their structural differences between groups. It is this difference that requires a theoretical explanation. Elliott (2000) allows us to interpret the results through the active nature of music education. The author considers music education as a practice in which thinking, emotion, and action form a single system. Our data are consistent with this concept, as the development of empathy and tolerance occurred simultaneously with the improvement of performance skills. However, the results expand the praxial approach, demonstrating that the nature of the activity determines the type of cognitive regulation that dominates the process of professional development.

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Vocalists show a clear increase in the cognitive aspect of tolerance. This is natural. Vocal practice involves analyzing the text, linguistic intonation, and cultural context of a piece. Small (1998) interprets music-making as a form of social interaction in which meaning is created through the exchange of meaning. Vocalists work with words, and words require interpretation. Thus, the acceptance of another musical tradition is formed through intellectual understanding of its content. Swanwick, (2008) emphasizes the importance of structural analysis of music for the development of musicality. In vocal training, this analysis is verbal-semantic in nature, which explains the dominance of the cognitive dimension. Authors Ranczakowska & Kuznetsova-Bogdanovitsh (2025) note that the development of tolerance and empathy in students contributes to their focus on solving complex professional, social, and cultural situations. Unlike previous studies, the results of our work reflect specific criteria for the development of empathy (the level of perception of emotions when interacting with other students; understanding the emotionality of musical works; the ability to convey musical signals) and tolerance (cognitive, motivational, behavioral, and meta-cognitive aspects) in future musicians. It was found that vocal students were primarily able to perception of emotions during interaction with other students (4.8 points). In students of group No. 2, the development of metacognitive skills (4.8 points) and perception of emotions through musical works (4.8 points) were primarily manifested.

Instrumentalists demonstrated the predominance of the metacognitive aspect. Their training is focused on technical accuracy, coordination, control of dynamics and timbre. Constant self-monitoring of the performance process forms mechanisms of reflective regulation. Thus, tolerance manifests itself not through primary analysis of content, but through the ability to adjust one's own strategies for action. This conclusion clarifies the position of Zhang (2025), who links emotional sensitivity to professional development but does not differentiate it according to the type of musical activity. The results also correlate with the data of Cui (2022) and Yang (2025) on the effectiveness of non-standard and digital approaches. However, unlike these works, which focus on technical progress, our study demonstrates their impact on socio-cognitive mechanisms.

The novelty lies in identifying different trajectories of tolerance development depending on specialization. The contribution to the discourse lies in clarifying the relationship between the type of musical activity and the dominant type of cognitive regulation. The practical conclusion is obvious. Educational programs should take into account the specifics of the training profile and purposefully develop both cognitive and metacognitive components of professional competence.

Conclusions

The results of the study showed that empathy and tolerance in future musicians can be developed using creative teaching methods. The novelty of the work boils down to achieving high-quality individual and group musical performance as a result of developing empathy and tolerance skills in future musicians using creative methods. It has been determined that tolerance skills allow for the perception of musical styles and genres, influence collective song performance, and increase intercultural competence and professional ethical competence. Empathy skills are reflected in the emotional perception of musical works, their expressive performance, and the formation of professional competence. After 15 weeks of training using the MSCEIT methodology, it was found that the tolerance skills formed in future vocalists (group No. 1) were cognitive skills; in future instrumentalists (group No. 2) – metacognitive skills. With their help, students were able to focus on the characteristics of musical works and their cultural significance. The use of the CIS

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scale made it possible to assess the development of empathy in students. It was found that students in both groups had developed skills in perceiving emotions during interaction with other students and through the perception of musical works. Students in group 1 were able to achieve high-quality group performance of musical works, while group 2 achieved high-quality individual performance. The limitations of the study are related to the absence of students with beginner and advanced musical skills. However, these limitations were not significant, as the study focused separately on vocal and instrumental students. Future research may include a detailed analysis of different musical genres to evaluate creative teaching methods and the development of tolerance and empathy skills.

Prospects for further research require greater specificity and methodological clarity. It is advisable to expand the sample by including students from different courses and several educational institutions, which will allow testing the stability of the identified differences between vocal and instrumental training. Special attention should be paid to the inclusion of a control group without the introduction of creative methods to establish cause-and-effect relationships. It is worth applying a longitudinal design with repeated measurements over several semesters to track the dynamics of the formation of cognitive and metacognitive components of tolerance. A promising approach is to combine psychometric instruments with neuropsychological or behavioral assessment methods. It is also advisable to analyze the influence of genre specificity of repertoire and the intensity of ensemble practice on the development of empathy. This approach will deepen our understanding of the mechanisms that determine the differentiated trajectories of musicians' professional development.

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Original Article

Digital competence and motivation as predictors of academic success in online training for university applicants

Competencia digital y motivación como predictores del éxito académico en la formación en línea de aspirantes universitarios

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Abstract

This study explores the impact of online education on the learning quality and academic achievements of higher education applicants. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework and Self-Determination Theory, the research adopted a mixed-methods design involving 270 participants. A 13-week online intervention combining real-time feedback, interactive modules, and collaborative forums was implemented. Data were analyzed using ANOVA, regression, Structural Equation Modeling (SEM), and cluster analysis. The findings indicate that participants possessed sufficient digital competence and high intrinsic motivation. Cluster analysis revealed three distinct learner profiles; the "Engaged-Tech-Savvy" group demonstrated significantly higher academic success compared to "Moderately Engaged" and "Disengaged" groups. Results confirm that digital competence and intrinsic motivation are key predictors of academic achievement, with course quality mediating this relationship. The study provides practical recommendations for higher education institutions regarding community building, digital infrastructure, and teacher training to better prepare applicants. Future research should integrate objective usage data to further validate these findings.

Keywords: Engagement, motivation, academic success, learning quality, digital technology.

Resumen

Este estudio explora el impacto de la educación en línea en la calidad del aprendizaje y los logros académicos de los aspirantes a la educación superior. Fundamentada en el marco del Conocimiento Tecnológico Pedagógico del Contenido (TPACK) y la Teoría de la Autodeterminación, la investigación adoptó un diseño de métodos mixtos con 270 participantes. Se implementó una intervención en línea de 13 semanas que combinó retroalimentación en tiempo real, módulos interactivos y foros colaborativos. Los datos fueron analizados utilizando ANOVA, regresión, Modelado de Ecuaciones Estructurales (SEM) y análisis de conglomerados. Los hallazgos indican que los participantes poseían suficiente competencia digital y una alta motivación intrínseca. El análisis de conglomerados reveló tres perfiles de aprendizaje distintos; el grupo "Comprometido y Tecnológico" (*Engaged-Tech-Savvy*) demostró un éxito académico significativamente mayor en comparación con los grupos "Moderadamente Comprometido" y "Desvinculado". Los resultados confirman que la competencia digital y la motivación intrínseca son predictores clave del rendimiento académico, con la calidad del curso actuando como mediadora

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en esta relación. El estudio ofrece recomendaciones prácticas para las instituciones de educación superior con respecto a la construcción de comunidad, la infraestructura digital y la formación docente para preparar mejor a los aspirantes. Futuras investigaciones deberían integrar datos objetivos de uso para validar aún más estos hallazgos.

Palabras clave: Compromiso, motivación, éxito académico, calidad del aprendizaje, tecnología digital.

Introduction

Globally, the educational system has been reshaped because of the advent of digital technologies in the teaching-learning process, shifting from the traditional method of teaching and learning to a virtual learning environment. According to Bazán-Ramírez et al. (2020), the shift from the traditional method of teaching to virtual environments became necessary because of the advent of the COVID-19 pandemic in early 2020. Globally, the COVID-19 pandemic forced many universities, colleges, and schools to shut down, and these educational institutions adopted emergency remote instruction. They also accelerated the integration of online teaching and learning models into their curricula. As Abdullah et al (2024) rightly put it, the shift has allowed learners residing in regions with scarce resources to access instructors and connect with high-quality content. Consequently, there is debate among researchers and other educational stakeholders on how online education impacts academic achievement, student motivation, cognitive outcomes, and the quality of the entire educational process. It is also pertinent for digital literacy, factors enhancing or reducing online education effectiveness, as well as individual trajectories, to be given concern among educators. The ability to utilize collaboration tools, address issues surrounding learning management systems, overcome and troubleshoot technical issues, and evaluate digital sources are some of the digital literacy skills that act as a gatekeeper, as learners who lack these basic digital literacy skills tend to have poor academic engagement and performance (Chávez-Miyauchi et al., 2021). Consequently, it becomes needful to ascertain the impact of online education on the quality of learning and academic achievement of applicants.

Across all stages of learning, it appears that online education, which is driven by the advancement of digital technologies and, more recently, by the outbreak COVID-19 pandemic, has evolved from is auxiliary instruction mode to the dominant format. Even though online education is a pervasive presence, the way it impacts the academic achievements of applicants for education is yet to be determined. There is debate whether the digital academic environment delivers inferior or superior educational quality when compared with the traditional method of teaching and learning. Despite these debates, there is still an absence of a comprehensive knowledge of the way and manner online teaching and learning influences the quality of the entire educational process, academic achievements, cognitive outcomes, and motivation. This apparent gap in knowledge persists because many studies conducted so far tend to focus on Massive Open Online Courses (MOOCs) or higher education, and they often do not address the distinct cohort of applicants more particularly those whose trajectories appear to be highly sensitive, as well as those who are at formal education threshold, which may lead to instructional delivery disruptions. These applicants are mainly graduates from secondary schools who are seeking admission into higher educational institutions to address present-day challenges such as disparate access to technology infrastructure, variable levels of digital literacy, and differing degrees of self-regulation. Unless how these factors

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interact with online modalities are thoroughly examined, it is difficult to discern the aspects of online education that enhance the quality of learning and which diminish it. For example, real-time discussion forums as well as interactive video lectures tend to enhance academic engagement and deeper understanding, while peer interaction that is insufficient, asynchronous modules that are poorly designed, and inadequate feedback mechanisms may hinder mastery of relevant concepts and erode motivation. In addition, many empirical studies conducted so far failed to capture the context of Ukraine. The educational system of Ukraine has its own resource problems, curricular standards, and socio-political environment. It shows a distinct set of circumstances that appears to affect the dynamics of the effectiveness of online learning. To date, there appears to be a paucity of robust and nation-wide research that carefully evaluated the impact of online formats on the indicators of academic performance or success, such as retention rates, entrance examination scores and graduation outcomes for applicants.

The general objective of this study is to examine the impact of online education on the quality of learning and academic achievement of applicants. Specifically, the study sought:

To analyze the level of satisfaction of participants with online education, their motivation and digital competences.

To empirically assess the academic achievements of participants, comparing them depending on the intensity and quality of online learning.

To identify factors (motivational, technological, pedagogical) that affect the quality of online education.

To build a statistical model that explains the change in academic results under the influence of online education.

To formulate recommendations for institutions that prepare applicants for entrance exams or study in higher education.

Hypotheses

H1. Intensive and structured online learning is positively correlated with academic achievements.
H2. Low digital competence reduces the effectiveness of online education regardless of motivation.
H3. Motivational factors (goal orientation, self-motivation) mediate the relationship between online education and success.
H4. The cognitive quality of online courses (clarity of structure, interactivity, feedback) is a predictor of high assessment results.
H5. Applicants with high levels of involvement in online learning demonstrate better success compared to groups with low participation.

Literature Review

The review of related literature are guided by the following subheadings:

Effects of Online Education on Quality of Learning

The role of online education in enhancing the quality of learning cannot be overemphasized. According to Chigisheva et al. (2021), online education

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significantly reshapes the online learning experience in ways that both diminish and enhance the breadth, depth, and durability of learning. Learning quality tend to improve when design in line with sound pedagogical principles. On the contrary, the absence of these sound pedagogical principles, according to Bravo-Agapito et al. (2021), more particularly when technology is not prudently utilized, it deters learning. Importantly, online frameworks such as Universal Design for Learning (UDL), backward design and constructive alignment clearly incorporate teaching design (Chávez-Miyauchi et al., 2021). As rightly stated by Zúñiga Rodríguez & Cáceres Mesa (2021), formative assessment are linked closely to focused measurable as well as learning objectives when content is separated into bite-sized modules. Examples of these formative assessments include polls, simulations and quizzes. In addition, concepts that are abstract in nature can be illustrated more clearly when compared with a textbook. In the words of Zapata-Garibay et al. (2021), there are different elements of multimedia which foster comprehension and clearer understanding such as videos, virtual labs and animations. When PDFs content is uploaded, records that are not properly edited with the absence of scaffolding may lead to cognitive overload, poor retention of what is being taught as well as engaging superficially with academic material. Be that as it may, the way and manner online education fosters education quality when compared to traditional approaches to teaching has become a matter of concern to many educational stakeholders all over the world. Arguably, instant feedback and structured academic environment are some of the benefits of traditional methods of teaching nu Turchyn et al (2023) maintain that digital teaching and learning process enhances an educational system that more interactive and flexible. In terms of motivation, be it extrinsic or intrinsic, digital education, serve as a tool by which learners develop ownership as well as self-discipline of their academic journey (Romero & Bobkina, 2021). Differently stated, the absence of physical classroom cues reduces pressure from peers for learners at the beginning stage with an attribute of strong self-regulatory skills. This often result to low motivational level due to the screens with isolated nature. Besides, Sapien Aguilar et al. (2020) is of the view cognitive outcomes including transfer of knowledge, retention of knowledge as well as critical thinking tend to crucial in terms of assessing and evaluative the effectiveness and efficiency of digital learning.

Effect of Online Education on Academic Achievement of Applicants

Studies have shown that online education impact academic success of applicants. In the words Dennis & Harrison (2021), engaging with instruction, changing the ways content are accessed by learners and demonstrating mastery are some ways online education reshapes academic achievement. A well-designed delivery model tend to boost academic achievement through data-driven personalization, flexible pacing and immediate feedback (Molina Gutiérrez et al., 2021). In this regard, Aldhafeeri, & Alotaibi. (2022) maintained that learners revisit difficult variables, replay video lessons and pause to take notes without pressure that stem from fixed classroom schedule, which may result in higher retention and deeper comprehension. Real-time insights into progress are provided through adaptive learning pathways, interactive quizzes and analytics dashboards and this enables reinforcement of weak areas and timely interventions, thereby lifting course grades and test scores (Kordrostami & Seitz. 2021). Academic achievement, which is often measured by test scores, grades, progression to higher levels of study and grade, Koseda et al. (2024) stated that students thriving in independent settings obtained better academic achievement because of the rapid proliferation of digital technologies into teaching and learning. They revisit materials at their convenient and also tailor pacing to their needs. On the contrary, students with poor family

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background, with inadequate access to digital technologies tend to experience higher rates of school dropout, slower progression and low grades (Landrum et al., 2020). Nevertheless, the same flexibility tends to place a heavy burden on self-regulation. According to Masalimova et al. (2022), applicants with the attributes of goal-setting, prudent time-management as well as metacognitive skills may capitalize on these benefits. This will help them achieve superior success when compared to traditional learners (Romero Alonso, et al. 2021). On the other hand, Romero & Bobkina, (2021) stressed that those applicants that lack discipline or motivation tend to miss deadlines, fall behind and as well perform poorly on course assessments, resulting to low graduation rates and poor academic performance.

Theories of Online Learning

Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical content Knowledge (TPACK) states that the effectiveness of teaching in the context of online academic environment is dependent on the integration three aspects of knowledge such as content, pedagogy as well as technological knowledge. However, technological content knowledge, pedagogical content, and technological pedagogical knowledge are the key variables of Technological Pedagogical content Knowledge (TPACK) that are created through the interaction of these three domains. Through these intersections, one can clearly understand and illustrate the ability to blend pedagogy content as well as technology. Technological Pedagogical content Knowledge (TPACK) therefore help educators to select digital tools that foster assessment, presentation and also scaffold pedagogical practices.

Technological Pedagogical content Knowledge (TPACK) is highly related to this research. This is due to the fact that applicant's academic outcomes appear to improve when Technological Pedagogical content Knowledge (TPACK) in included in the academic environment. Hence, Technological Pedagogical content Knowledge (TPACK) serve as a platform through which applicants incorporate digital tools including simulations, data visualization as well as interactive videos. All these digital tools help applicants to determine and understand variables that are difficult and also enhance their acquisition of skills. Thus when the prudent use of digital technology only for PDFs uploading makes learning superficial which reduces motivational level of learners. It becomes necessary to use Technological Pedagogical content Knowledge (TPACK) in terms of enhancing quality learning.

Self Determination Theory (SDT)

The Self Determination Theory (SDT) which was propounded in the 1980s and refined later in 2000 states that autonomy, competence as well as relatedness are the three innate emotional needs that undermine intrinsic level of motivation and optimal learning. According this theory, autonomy refers to the act of giving students control and choice regarding their academic journey which enhances a sense of ownership. In terms of competence, there is usually a feeling that is effective in terms of mastering tasks and this feeling is usually encouraged by clear learning objectives and constructive feedback. Relatedness simply means interaction as well as a sense of belonging with friends, age mates and teachers which promotes motivation and academic wellbeing.

Self Determination Theory (SDT) is also related to the present study because motivational levels of applicants may increase when autonomy is enhanced via skill mastery, flexible pacing, personalized research topics as well as modules. Also,

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motivational level of applicants tend to increase when digital badges, adequate feedback and scaffolding assignments are given. Thus, using collaborative discussions, mentorship and group projects to build relatedness goes a long way to cultivate a learning community. On the contrary, the neglect of these variables may lead to poor engagement and learning outcomes of applicants.

Issues of Academic Integrity

It is vital for applicants to complete their task painstakingly with the absence of plagiarism, unauthorized aid and teaching because of the way and manner educational system has been transformed using digital tools and resources. According to Regalado-Pezua & Galeano (2022), the term light simply means physical illumination and it also denotes words like awareness visibility as well as transparency. As stated by Knopf et al. (2021) when visibility is built intentionally into the design of platforms, policies as well as assessments, it addresses the integrity related problems. In addition, Kordrostami & Seitz (2021) maintained that examination malpractices is lower when evaluations are not properly monitored. Apart from that, the use of simple task including time stamps, transparency layers and a single sign on (SSO) systems tend to reduce dishonesty. According to Realyvásquez-Vargas et al. (2020), assessment process that is transparent and open reduces ambiguity. Hence, it goes a long way to reduce academic misconduct. In this regard, Landrum et al. (2020) noted that rubrics, visible expectations as well as criteria for grading aid learners to clearly understand variables that influence acceptable collaboration as well as cheating. Hence, open-book examinations with higher-order questions, such as application analysis and synthesis, shift the focus from memorization to mastery demonstration and make it more challenging to gain an unfair advantage by searching for online answers (Turchyn et al., 2023; Morgulets & Derkach, 2019; Quispe-Prieto et al., 2021).

Factors of Success, Motivation, Self-Regulation, Digital Skills- How Each Improves Online Learnings

Online teaching and learning are effective when the necessary success factors are in place. This is because well-structured modules and clear learning goals provide students with a channel to progress academically and reduce ambiguity (Zhao et al., 2023). In addition, Abdullah et al. (2024) posited that mastery is reinforced through prompt, specific feedback, whereas timely technical support prevents frustration and school dropout rates. However, intrinsic and extrinsic motivation tend to drive academic engagement. According to Chávez-Miyauchi et al. (2021), learners are equipped with time management, goal setting, adjustment strategies, and self-regulated monitoring of understanding. Also, routines are built among learners through calendar reminders, structured schedules, and modular deadlines. There are many tools, such as learning analytics dashboards, journals, and self-assessment quizzes, that enhance awareness of the metacognitive process. As rightly stated by Chigisheva et al. (2021), friction is removed from the learning process through proficiency with digital technologies. Learners focus on content rather than technology through collaboration suites like Zoom, Teams, and Google Workspace, and also address basic troubleshooting (Aldhafeeri, & Alotaibi, 2022; Kovačević et al., 2021; Guillén-Gámez & Mayorga-Fernández, 2020). Conclusively, academic integrity and quality of work will be enhanced when there is an absence of plagiarism, references being digitally managed, and evaluating sources. Based on the literature reviewed so far, many studies, to the best of our knowledge, lack empirical evidence. The reviewed studies were based on mere observations and theory, thereby creating an

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empirical gap to cover. This apparent knowledge gap makes the present study germane.

Methodology

Research Type

The study adopted a mixed methods design, combining a qualitative focus group and a quantitative survey with an achievement-test block component. A quasi-experimental design, using pre-test and post-test measures, was employed within the quantitative strand to compare results across different levels of online participation. The study was therefore structured with a correlational component and a controlled experimental component, such as low-intensity or traditional control groups. versus high intensity online learning with the sole aim of exploring moderating and mediating factors.

Study Sample

The study sample consists of 270 participants, including students, teachers, and administrative staff from higher institutions offering online programs. Content related to sharing LMS data on usage and active enrollment in the online preparatory program was required for the study. Additionally, the researchers stratified participants by online engagement level—low, medium, and high—using LMS log metrics, including module completion, hours accessed, and interaction frequency. Therefore, gender representation, prior levels of digital competence, and discipline were ensured through random sampling within each stratum (See Table 1).

Table 1.
Participants Demographic data

Intensity	Sex (M/F)	Digital Competence	Discipline(n)	Total	%
High (>8h/w,>70% completion)	M=48(51.6%) F=45(48.4%)	Advanced=55(59.6%) Basic= 8(8.6%) Intermediate= 30(32.3)	Education= 30 Business= 25 Health Science=8 Engineering=3	93	34.4
Medium (4-8h/w,30-70% completion	F=57(54.3%) M=48(45.7%)	Advanced=40(38.1%) Basic= 0(0%) Intermediate= 65(61.9)	Arts= 22 Social Sciences= 35 Computer= 18 Engineering=30	105	38.9
Low (≤ 4h/w, ≤ 30% completion)	M=32 (44.4%) F= 40 (55.6%)	Intermediate 27 (37.5%) Advanced 0(0%) Basic 45 (62.5%)	Education= 45 Business= 12 Health =15	72	26.7
Age	18-24= 80(29.6%)	25-34=120 (44.4%)	35-44= 50 (18.5%)	45-54= 15 (5.6%)	55 and above= 5 = 1.9%
Prior Educational background	High school Diploma= 50 (18.5%)	Bachelors' Degree = 150 (55.6%)	Master's Degree = 50 (18.5%)	Doctoral Degree= 20 (7.4%)	Total= 270

Reliability of Instruments

The Cronbach Alpha method was used to conduct a trial test with similar study participants for the three instruments outside the study area. The Motivation for Online Learning Inventory (a= 0.92), Online Learning Quality Scale (a=0.87), as well as academic Performance Test (pre-test a= 0.81. post-test a=0.78). All these

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instruments showed acceptable internal consistency and for the current sample to reconfirm reliability, Chronbach alpha values are computed.

Data Collection Methods

In this study, the Online Learning Scale (OLOS), a 30-item Likert instrument, is used, covering interaction, individualization, structure, and technical support. The Academic Performance Test (APT) consists of a second-semester examination and a standardized 50-item test aligned with program learning outcomes. Self-motivation. Intrinsic and extrinsic motivation are measured using the Motivation for Online Learning Inventory, which contains twenty items. The Digital Competence Scale (DCS) was adapted from the DigCompEdu framework. The instrument employed for the collection of data is made up of 25 items measuring communication, digital literacy, safety, the handling of information, the creation of content as well as problem solving. In addition, EdTech Usage questionnaire was developed by the researchers. The questionnaire covered the perceived usefulness of simulations, video lectures, LMS features as well as video lectures.

Procedure

Ethical approval, informed consent and the collection of baseline information were secured by the researchers. However, the researchers conducted the intervention from week one to twelve and they ensured that study respondents participated in the low, medium and high digital learning intensities. They also recorded participation metrics in LMS logs. The activities in the intervention involved reflection journals, weekly modules and synchronous webinars as well as two collaborative case studies. In addition, teachers received training for four hours on LMS tools and different instructions while LMS analytics, 10% audit of sessions and bi weekly facilitator checklist were monitored using Fidelity. Furthermore, there was an occurrence of posttest administration in week 13 and in week 14, a focus group interview was conducted which involve 30 participants. This interview provided insights on perceived digital competence, quality as well as motivational levels and the research team stored, accessed and also anonymized the collection of data from the respondents.

Data Analysis

This research made use of different statistical tools for analyzing data. In this regard, standard deviation frequency distributions as well as mean were employed to analyse digital competence, motivational levels OLQS dimensions and satisfaction scores. In addition, Independent t-test as well as one-way ANOVA were adopted in the study. Pearson correlation analysis examined relationships among the study variables. Multiple regression models predicted post-test scores while controlling for OLQS variables, pre-test performance, digital competence, and motivation. Structural equation modeling tested for moderation and mediation effects on students' academic achievement. Cluster analysis identified distinct learner profiles for recommendations. All analyses were conducted using SPSS version 28.

Ethical Considerations

The researchers obtained written consent and notified study participants that participation was voluntary and that they had the right to withdraw from the study if needed. Besides, confidentiality and anonymity were maintained in this research and ethical guidelines were painstakingly followed.

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Results

The results of this study are discussed below. The data in Table 1 show that intrinsic motivation, digital competence, and satisfaction are above the midpoint of the scale. It means that participants' perception regarding the online environment is positive because they felt capable with the digital technologies used.

Table 2.
Descriptive Statistics

Variable	Mean	SD	Min	Max
Satisfaction (OKQS)	3.82	0.71	1.0	5.0
Intrinsic Motivation (MOLI)	3.94	0.68	1.0	5.0
Extrinsic Motivation (MOLI)	3.45	0.79	1.0	5.0
Digital Competence	3.72	0.63	1.0	5.0

Intrinsic motivation (M = 3.94, SD = 0.68) had the highest mean score among all variables. This result showed that learners were driven by enjoyment, personal value in line with learning process and intrinsic interest. This is a type of digital learning environment where self-paced learning as well as autonomy enhanced internalized motivation. Satisfaction with online learning (M = 3.82, SD = 0.71) was relatively high. Thus, students perceived the online courses as well-organized. Digital competence (M = 3.72, SD = 0.63) was slightly lower than intrinsic motivation and satisfaction, but still had a positive trend.

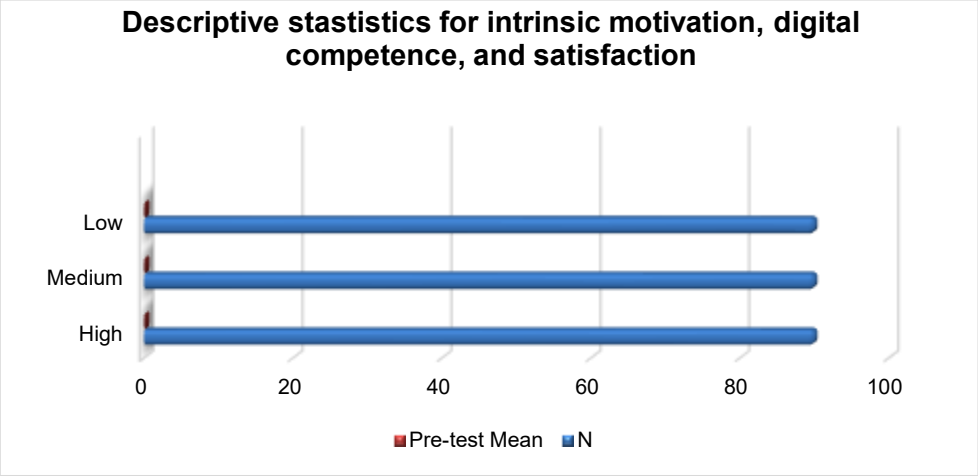


Figure 1. *Participants' perception regarding the online environment*

Table 3.
Academic Performance by Intensity of Engagement

Intensity	N	Pre-test Mean	Post-Test Mean	Mean	T
High	90	65.4(11.8)	77.5 (12.3)	12.1	7.32
Medium	90	62.0(12.6)	71.2 (13.0)	9.2	5.89
Low	90	59.5 (12.1)	66.8 (12.9)	7.3	4.15

Data in Table 3 revealed that all the participants in the intensity groups indicated significant gains from pre-test to post-test. This is because the pre-test mean score on the Academic Performance Test was lower than the post-test score, and the paired t-test showed a significant improvement. However, the high intensity group obtained the largest score increase, and it was followed by medium and low.

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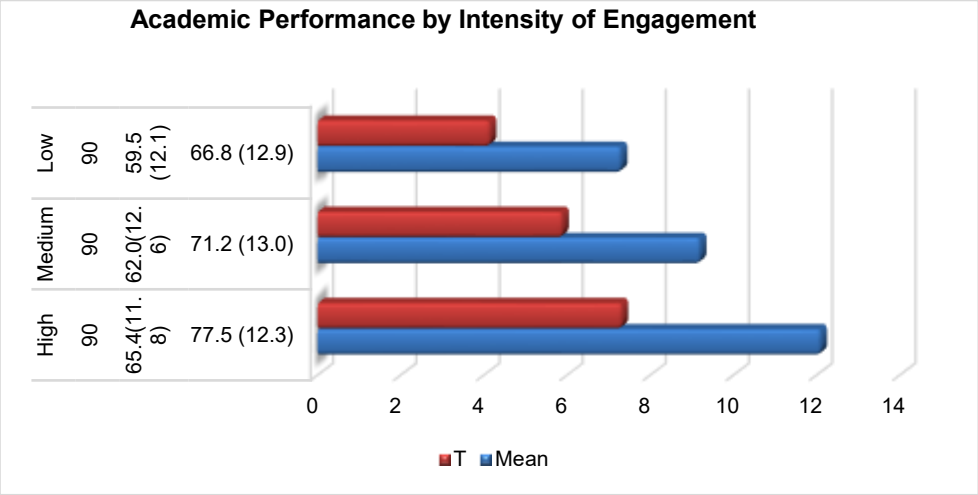


Fig 2. *Academic Performance of pre-test and post-test by Intensity of Engagement*

Table 4.
ANOVA for difference across Intensity Groups (Post-test Score)

Source	Sum of Squares	Df	Mean Square	F	P	η²
Between Groups	1268.4	2	634.2	6.48	0.002	0.046
Within Groups	26145.6	267	97.9			
Total	27414.0	269				

In Table 4, ANOVA was used to test whether the post-test mean score will differ significantly across high, medium, and low levels of intensity. ANOVA result ($F(2,267) = 6.48$, $p = 0.002$) shows a statistical significant difference across the three independent groups (high, medium and low intensity), but with small effect size ($\eta^2 = 0.046$).

Table 5.
Correlation Matrix

Variables	Satisfaction (OKQS)	Intrinsic Motivation (MOLI)	Extrinsic Motivation (MOLI)	Digital Competence	Post-test Score
Satisfaction (OKQS)	1.00	0.48 **	0.31 **	0.42 **	0.39 **
Intrinsic Motivation (MOLI)	0.48 **	1.00	0.27 **	0.35 **	0.51 **
Extrinsic Motivation (MOLI)	0.31 **	0.27 **	1.00	0.19 **	0.22 **
Digital Competence	0.42 **	0.35 **	0.19 **	1.00	0.44 **
Post-test Score	0.39 **	0.51 **	0.22 **	0.44 **	1.00

*p< 0.05, ** p < 0.01

In Table 5, Pearson correlation matrix was used to determine the relationship between extrinsic motivation, intrinsic motivation, post-test academic performance and digital competence. The analysis helps determine how these variables co-vary and whether competence and motivational factors align with higher academic Achievement and perceived quality of education. The results indicated that satisfaction was moderate. Positive, digital competence correlates significantly both post-test performance and satisfaction, extrinsic motivation significantly, though statistically significant, shows weaker relationship whereas intrinsic motivation has the strongest link to post-test score. The pattern of correlation in Table 4 supports

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that digital competence and motivational elements, especially intrinsic motivation, are major factors that influence academic achievement and the quality of education.

Table 6.
Regression Coefficients

Predictor	β (Standardized)	SE	T	P
Pretest score	0.32	0.05	6.40	< 0.001
Intrinsic motivation	0.28	0.06	4.67	< 0.001
Digital competence	0.22	0.07	3.14	0.002
OLQS (Quality)	0.15	0.06	2.50	0.013
Intensity (High versus Low)	0.12	0.05	2.40	0.017

Data in Table 6 reveal that pretest score remains the strongest predictor while digital competence and intrinsic motivation also have substantial effects. Also, intensity of participation contribute modestly. These findings implies that both technology proficiency and higher internal drive enhance academic achievement. The implication is that both level of engagement and quality of design matter.

Table 7.
SEM path Coefficients

Path (From → To)	Standardized β	SE	P
Intrinsic Motivation → Post-test Score	0.30	0.05	< 0.001
Digital Competence → Post-test Score	0.24	0.06	< 0.001
OLQS (Quality) → Post-test Score	0.16	0.05	0.002
Intensity (High vs Low) → OLQS	0.21	0.04	< 0.001
Motivation (Intrinsic) → OLQS	0.19	0.04	< 0.001
Post-test Score → Post-test Score	0.34	0.05	< 0.001

Data in Table 7 reveal a good model fit. This is because both digital competence and intrinsic motivation directly affect academic achievement, whereas OLQS quality partially mediates the effect of motivation and intensity on performance.

Table 8.
Cluster Profiles (Mean Scores)

Variable	Cluster 1 (n= 92)	Cluster 2 (n= 85)	Cluster 3 (n= 93)
Intrinsic motivation	4.56	3.71	2.85
Digital Competence	4.32	3.68	2.94
OLQS (Satisfaction)	4.45	3.79	2.98
Intensity (Hours/week)	12.4	7.8	4.5
Post-test Score	78.9	70.5	63.1
Profile Label	Engaged-Tech-Savvy	Moderately Engaged	Disengaged-Low Competence

Cluster 1 (Engaged-Tech-Savvy) shows the highest intensity and achievement, motivation and competence. Cluster 2 (Moderately Engaged) falls within the mid-range while cluster 3 (Disengaged-Low Competence) obtained the lowest result across competence, motivation, engagement, and performance. Hence, one can infer that distinct learner profiles respond to the quality of online education differently.

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Table 9.
Recommendations for institutions that prepare applicants for entrance exams

S/N	Questionnaire Item	Mean	SD	Remark
1.	The module objectives should be easy to follow	3.21	0.68	Agree
2.	Feedback should be timely	3.04	0.75	Agree
3.	LMS interface should be reliable	2.78	0.84	Agree
4.	Learners should be engaged with interactive elements	3.12	0.71	Agree
5.	Learners should be given technical support	2.86	0.79	Agree

Data in Table 9 show that all the items were rated agreed by the study participants, indicating that all the items are the ways higher educational institutions can prepare applicants for entrance examinations.

Hypothesis 1: Intensive and structured online learning is positively correlated with academic achievements

Table 10.
Test of Hypothesis 1

Variable	r(Pearson)	p-value	β (Regression)	SE	t
Intensity (hours/week)	0.34	< 0.001	0.12	0.04	3.00
Pre-test Score (Control)			0.31	0.05	6.20

Data in Table 10 shows that a higher intensity of engagement shows a moderate relationship with larger test score gains. Ever after adjusting pre-test performance, intensity still remains a significant predictor. The implication is that intensive and structured online learning is positively correlated with academic achievements.

Hypothesis 2: Low digital competence reduces the effectiveness of online education regardless of motivation.

Table 11.
Test of Hypothesis 2

Variable	β (Regression)	SE	T	P-value
Pre-test Score	0.33	0.05	6.60	< 0.001
Digital Competence (DCS)	0.22	0.07	3.14	0.002
Intrinsic Motivation	0.28	0.06	4.67	< 0.001

The hypothesis tested in Table 11 indicated that intrinsic motivation and digital competence both significantly predict post-test scores after controlling for pre-test while the positive coefficient for DCS indicated that higher competence improves performance. The result therefore show that Low digital competence reduces the effectiveness of online education regardless of motivation.

Hypothesis 3: Motivational factors (goal orientation, self-motivation) mediate the relationship between online education and success.

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Table 12.
Test of Hypotheses 3 (Mediation Results)

Path	Standardize β	SE	P-value
OLQS→Instrinsic Motivation (a)	0.48	0.04	< 0.001
Intrinsic Motivation→ Post-test (b)	0.30	0.05	< 0.001
Direct: OLQS→ Post-test (c)	0.16	0.05	0.002
Indirect effect (a x b)	0.14	0.3	< 0.001

The hypothesis tested in Table 12 shows that intrinsic motivation was strongly predicted by OLQS, and intrinsic motivation predicts post-test scores. The indirect effect accounts for 48% of the total effect of OLQS on post-test, showing that mediation was partial. The implication is that motivational factors mediate the relationship between online education and success.

Hypothesis 4: The cognitive quality of online courses (clarity of structure, interactivity, feedback) is a predictor of high assessment results.

Table 13.
Test of Hypotheses 4

Predictor	β (Standardized)	SE	T	P-value
Pre-test Score	0.32	0.05	6.40	< 0.001
OLQS (Quality)	0.15	0.06	2.50	0.013
Intensity (High vs. Low)	0.12	0.05	2.40	0.017
Digital Competence	0.22	0.07	3.14	0.002

In Table 13, OLQS reveals a modest but significant effect, indicating that higher perceived course quality predicts better post-test performance after adjusting for competence, intensity and pre-test. This means that the cognitive quality of online courses (clarity of structure, interactivity, feedback) is a predictor of high assessment results.

Hypothesis 5: Applicants with high levels of involvement in online learning demonstrate better success compared to groups with low participation

Table 14.
Cluster profiles for Hypotheses 5

Cluster	N	Intrinsic Motivation	Digital Competence	Intensity	Post-test	Profile Label
1	92	4.56±0.42	4.32±0.45	12.4±0.45	78.9±8.2	Engaged-Tech-Savvy
2	85	3.71±0.49	3.68±0.53	7.8±1.5	70.5±9.4	Moderately Engaged
3	93	2.85±0.61	2.94±0.57	4.5±1.2	63.1±10.3	Disengaged-Low Competence

Table 15.
ANOVA on post-test Score (Cluster Difference)

Source	Sum of Squares	df	Mean Square	F	P	η^2
Between Groups	12684.3	2	6342.15	42.3	<0.001	0.31
Within Groups	28,329.7	267	106.10			
Total	41014.0	269				

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In table 14, the ANOVA revealed that a statistically significant difference across all clusters- (Engaged-Tech-Savvy), (Moderately Engaged) and Disengaged-Low Competence. This difference also has large effect size.

Table 16.
Pairwise Tukey HSD (95%CI)

Comparison	Mean Difference	95% CI	P
Cluster 1vs2	8.4	5.2→11.6	< 0.001
Cluster 1vs3	15.8	12.6→ 19.0	< 0.001
Cluster 2vs3	7.4	4.2 → 10.6	< 0.001

In Table 16, the Tukey post-hoc tests showed that every pairwise comparison was significant. Simply interpreted, applicants with high levels of involvement in online learning demonstrate better success compared to groups with low participation

Discussion

The findings of the study, in accordance with the first objective of this study, indicated that study participants exhibited a high satisfaction level with online education. This result was probably obtained because of the personalized and interactive nature of the academic environment, allowing learners to receive feedback on time and also engage actively with multimedia resources. Items such as clear objectives and content alignment showed that the modules were structured very well. To support this result, Delgado (2021) and Flores Ferro et al. (2021) agreed that AI powered platforms fosters learning effectiveness via real-time feedback as well as adaptive pathways, supporting digital technologies for enhancing learning satisfaction as well as the development of digital competence

Secondly, the result of this study revealed that learners in clusters, more particularly those who supported that higher academic engagement led to better academic results when compared with learners opinion in moderately engaged and disengaged groups. This result showed that participation intensity as well as digital competence go a long way to foster students' academic outcomes. Besides, the result of ANOVA showed the presence of a large effect, indicating that 31% of the variance scores is determined by engagement level. Moreover, the result of Tukey HSD post-hoc tests revealed differences among all peers, indicating that when there is high engagement as well as digital competence, it leads to excellent academic outcomes. This finding is consistent with the findings by Romero Alonso et al. (2021) and Salas-Pilco & Yang (2020) that when the self-directed learning and motivational level of learners are high, they perform better academically. The results of this research also determined the factors shaping the quality of digital education such as digital competence as well as intrinsic motivation. The study maintained that intrinsic motivation mediates the cordial affinity between excellent academic achievement and perceived quality of learning (Kulichenko et al., 2018; Polyezhayev et al., 2024). Besides, multiple regression showed that both intrinsic motivation and digital competence are significant predictors of post-test scores. Mediation analysis also indicated that intrinsic motivation partially mediates the affinity between perceived quality of learning and academic achievement. The moderation result also revealed that digital competence moderates the motivation-performance link. This suggests that motivation is more impactful for students with higher competence (Bond et al., 2020; Bazán-Ramírez et al., 2020).

These findings reinforce the relevance of technological and motivational dimensions. In this regard, Prokopenko et al. (2024) reported that teacher training and technical

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support for the successful integration of AI enhance the adoption of digital technologies in online education. The findings of the study demonstrated that post-test performance was positively predicted by the perceived course quality (OLQS), more particularly after controlling for intensity, digital competence, as well as pre-test scores. The correlation matrix showed that moderate positive relations between OLQS, motivation and post-test reinforce the interdependence of these variables. This result implies that interactivity, adequate and timely feedback, and structure clarity contribute to learning gains; hence, they are not merely cosmetic. The result of this study is in agreement with the findings by Ferrer et al. (2022) and Lovón Cueva & Cisneros Terrones (2020) that assessment results drive cognitive quality of online education. Finally, the findings of the study revealed some of the key recommendations for higher educational institutions preparing applicants for entrance examinations including- enhancing a sense of community through peer activities that are structured, using targeted training modules to strengthen digital competence, improving the usability and stability of the LMS, and maintaining a good alignment between the content of examinations as well as their outcomes (Pichkur et al., 2023). This study, however, was limited by the sample size of 270 participants, which makes it difficult to generalize the study findings. This is because it may not represent all the applicants from diverse socioeconomic backgrounds. In addition, transfer effects and insights into long-term retention may be restricted because of the short 13-week intervention period. Over-reliance on self-reported measures, particularly for digital competence as well as motivation, tends to introduce technical issues and response bias from the study participants. Perhaps, this may have hindered levels of engagement for the disengaged-low competent cluster.

Conclusions

This research investigated the impact of digital education on the quality of learning and academic outcomes of applicants who prepare for advanced examinations in higher institutions. The results of this research revealed a high satisfaction level among applicants with regard to content relevance, timely feedback and course clarity. The results also indicated that strong motivation as well as adequate digital competence were available. It was deduced that perceived quality of academic environment and engagement intensity came up as predictors of enhanced post-test scores. The results showed a distinct profile of applicants, stressing that participants in the group with a higher level of academic engagement obtained better academic outcomes than those in the disengaged and moderate groups. Hence, motivation, digital competence, and active participation foster academic outcomes. This research showed that academic performance of learners will improve peer structured activities are used, targeted training modules are used to foster a sense of community, enhance digital competence, improve stability and usability of LMS, and also maintain a good relationship between examination content and outcomes. This will foster effective personalized learning. Based on the foregoing, future research that will be conducted in Ukraine should therefore extend the periods of intervention and also ensure the expansion of the participant pool, complement, and add meaning to the results obtained via the survey. Addressing these gaps in knowledge will help future researchers to build a sustainable and all-inclusive model to prepare applicants who intend to write entrance examinations in high academic institutions

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Original Article

ICT-Based adaptation of educational programs: A methodological model for student mobility in crisis contexts

Adaptación de programas educativos basada en las TIC: un modelo metodológico para la movilidad estudiantil en contextos de crisis

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Abstract

The full-scale war in Ukraine has significantly altered students' educational trajectories, forcing many to continue their studies abroad while facing digital, organizational, and psychosocial barriers. This study addresses the challenge of maintaining accessibility and quality of higher education under conditions of high mobility, instability, and emotional stress. Its purpose is to identify key obstacles to studying abroad during wartime and to assess the effectiveness of adaptive mechanisms implemented by Ukrainian universities. The research applies content analysis of academic sources and statistical and comparative analysis using data from the United Nations Development Programme and Ukrainian educational analytics. The findings indicate that flexible educational pathways, supported by digital competencies, organizational agility, and psychosocial assistance, contribute to the stability of students' learning trajectories. Despite a decline in the number of universities, student enrollment remains relatively stable, indicating structural adjustment rather than system degradation. Although displaced students experience greater psychological and communicative challenges, flexible schedules, blended learning, and digital technologies are associated with reduced dropout rates and improved academic outcomes.

Keywords: adaptation of educational programs, digital accessibility, distance learning, psychosocial barriers, students abroad.

Resumen

La guerra a gran escala en Ucrania ha alterado significativamente las trayectorias educativas de los estudiantes, obligando a muchos a continuar sus estudios en el extranjero y a enfrentar barreras digitales, organizativas y psicosociales. Este estudio aborda el desafío de mantener la accesibilidad y la calidad de la educación superior en condiciones de alta movilidad, inestabilidad y estrés emocional. Su objetivo es identificar los principales obstáculos para estudiar en el extranjero durante el conflicto armado y evaluar la eficacia de los mecanismos de adaptación implementados por las universidades ucranianas. La investigación aplica análisis de contenido de fuentes académicas y análisis estadístico y comparativo utilizando datos del Programa de las Naciones Unidas para el Desarrollo y de la analítica educativa de Ucrania. Los resultados indican que las trayectorias educativas flexibles, respaldadas por competencias digitales, agilidad organizativa y apoyo psicosocial, contribuyen a la estabilidad de los itinerarios formativos. A pesar de la disminución del número de universidades, la matrícula estudiantil se mantiene relativamente estable, lo que evidencia un ajuste estructural y no una degradación del sistema. Aunque los estudiantes desplazados enfrentan mayores dificultades psicológicas y comunicativas, los horarios flexibles, el aprendizaje híbrido y las tecnologías digitales se asocian con menores tasas de abandono y mejores resultados académicos.

Palabras clave: adaptación de los programas educativos, accesibilidad digital, aprendizaje a distancia, barreras psicosociales, estudiantes en el extranjero.

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Introduction

The full-scale invasion of Ukraine led Russia to require high students to continue higher education in foreign countries, which continue to enroll in Ukrainian universities and face novel digital, institutional, and psychosocial threats. Innovations in the forms of distance and hybrid learning have made the issue of access, continuity, and mental health especially challenging due to learning in new sociocultural settings (Alawadhi, 2024; Sych et al., 2025). According to the literature, the issues are broken educational pathways, challenges in adapting to new pedagogical principles, and experiencing an elevated level of psychological stress among foreign Ukrainian students (Chala et al., 2024; Pentón Herrera & Byndas, 2023; Oleksiyenko & Shchepetylnykova, 2024). Even though digital tools and competence-based learning environments are actively promoted as custom-made solutions (Batsurovska et al., 2021; Ihnatenko & Shorena, 2024), only a limited number of studies have empirical data on their ability and success as instruments to promote long-term academic resilience and psychosocial adjustment during forced mobility.The main goals of my study are to find out what problems and needs students have when they are studying abroad during times of armed conflict, how changes in education indicators and psychosocial characteristics are shown using statistical data from both national and international levels, how well Ukrainian higher education institutions are adapting to new problems, and to provide a complete model of how universities can respond so that students can continue their own education despite the cross-border situation.

Literature Review

The issue of ensuring the quality of higher education and supporting students during armed conflicts is actively researched in the literature. A significant part of the work is devoted to the transformation of education systems during periods of large-scale crises, in particular the impact of war on the functioning of universities, student mobility, and the adaptation of educational programs. For instance, a number of studies analyze the general consequences of war for higher education (on the decline in the quality of educational services) and problems with the organization of learning, changes in strategic approaches to managing institutions in conditions of instability (Alawadhi, 2024). At the level of organizational processes, issues of the effectiveness of displaced universities and the results of their adaptation to new regional and international conditions are highlighted (Sych et al., 2025; Orzhel et al., 2023).

Meanwhile the study in student mobility and of these concrete experiences when they move, becomes increasingly important because they have to move. (Chala et al., 2024; Pentón Herrera & Byndas, 2023; Oleksiyenko & Shchepetylnykova, 2024) on students' educational pathway at schools and difficulties they experience in school as well as consequences of disrupted education including application of special adaptation measures applied by host countries. During war times, the researchers found evidence of large swings in why people from Ukraine moved for school and in how much social and safety concerns influenced their decision on a school. Competency-based implications, technological instruments and a new teaching style of educational can be very beneficial to students when they are in need of help or assistance (Batsurovska et al., 2021; Bond et al., 2021; Crawford et al., 2020; Bozkurt & Sharma, 2020; Okeke-Uzodike & Ngo Henha, 2025).

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Simultaneously, the studies on education in emergencies also highlight the fact that pedagogical innovation cannot be applied solely without the systemic coordination and enabling governance structures. Menashy & Zakharia (2023) show that cross-sector collaboration can be a key to sustainable educational continuity in crisis settings in line with SDG 4 and SDG 17, and Dupuy et al. (2022) show how regulation prohibitions in the host countries can severely limit the formal access of refugees to education. Shah et al. (2024) also suggest that to reimagine education during emergencies, it is necessary to bridge the policy discourse and practitioners experience so that the institutional response is both contextualized and equity-focused.

Even though institutional access to education is determined by structural governance frameworks and regulatory environments, the ultimate success of these processes is determined by the psychosocial adaptability of displaced students to learn under states of uncertainty and extended stress. Much has been written about these students and refugees, their mental and social status in Ukraine as well as Ukrainians who abroad because one of the prerequisites is their psycho-emotional state for more successful learning in schools. Their stress level and the feeling of being safe is directly related with study behavior. International research has identified a long list of issues that complicate and where you are they have to learn how to access the health, social services and school systems of new places to which Ukrainians move. These are language, culture, society and institutional organization (Benoni et al., 2025; Whitehead et al., 2025; Ellis et al. 2024). Research on mental health and well-being of Ukrainians who have fled their homes has shown: the importance of system support and availability of services as well as patterns for interaction between sectors (Buchcik et al., 2023; Gishlarkaev et al., 2025; Vereshchakina et al., 2023). It is not surprising that the amount of state support and the little more holistic social and environmental context proved to be so important in determining how well Ukrainians have settled into their transitional home (Berg, 2023; Bozorgmehr et al., 2024).

Literature focusing on methodological and ethical issues of research in cases of emergencies has stressed that context sensitive, interdisciplinary, and practice-based methodology should be applied to data collection and analysis in unstable situations (Shah et al., 2024). These approaches lay the groundwork for developing new forms of support for students who find themselves abroad due to war and for forming effective models for adapting educational programs to conditions of high mobility and stochasticity of academic trajectories.

Continuing the review of the literature, it is important to highlight the contribution of researchers who focus on systemic transformations and management decisions during wartime. For example, the issue of the strategic capacity of Ukraine's higher education system is covered in detail in analytical works that identify factors of resilience and institutional adaptation during a large-scale crisis (Zayachuk, 2024). Particularly, it is essential to learn about the ways various countries manage refugees, strengthen social systems and keep services running in course of mass movement (Bozorgmehr et al., 2024). These papers make clear that cross-cutting policies now play a greater role, and one needs to think about choices over education in light of larger themes of security and humanitarianism.

The studies of the health and wellbeing also give valuable indications of the factors that directly affect the ability of the displaced students to participate in the learning. Research on the stressors, the availability of access and service, and the psychosocial vulnerability of refugees in Ukraine proves that emotional stress and structural obstacles could impair academic engagement and educational

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persistence (Whitehead et al., 2025). Social and health services research indicates that both the problems of access and level of cognitive load negatively affect student achievement in school and unengagement from the learning process (Whitehead et al., 2025). The study by Brunner et al. (2025) conducted in 2025 makes clear that university refugee and displaced student policies have two sides. This study demonstrates how official ways of "caring" for such students can be construed as a form of control that has implications in terms of the resource and access, academic trajectories, and possibilities to belong within host school contexts.

Ethical and epistemological aspects of investigating education in case of emergency situations also need to be reviewed critically, especially concerning the aspects of power relations, collaboration between practitioners and scholars, and situational production of knowledge (Shah et al., 2024). This is a particularly important domain for developing questionnaire tools and approaches to identifying the educational needs of learners studying overseas in unstable conditions. In relation to the displaced groups, those studies which focus on inter-disciplinary approach and development of inclusive models of analysis are unanimous regarding the need for culturally sensitive, flexible and robust research strategies (Benoni et al., 2025; Vereshchakina et al., 2023).

Taken as a whole, new scientific research indicates there has been plenty of progress in figuring out how war impacts on students' education, mobility, mental and emotional health. But it also reveals some remaining issues that aren't yet fully understood. First, the strategies for integration of Ukrainian educational programs in foreign systems of education should be developed. Also models of long-term support for students who chose to study or have to live abroad, need developing in relation to high mobility and forced life situation.

Methodology

The research was organized and implemented on the basis of an analysis and interpretation of official statistical data from open international (including United Nations Development Programme (further – UNDP) report "The impact of war on young people in Ukraine") and national sources, Ukrainian Education Analytics analytical reports as well as scientific publications (including those about College resilience during wartime). In order to obtain the results, the method of content analysis of scientific works, the comparative-analytical method for developing comparisons-traditional trends in education at foreign universities, quantitative analysis for processing statistical indicators over 2020–2024 and a combination-period generalized way to determine of key barriers and needs for students are studying abroad. The statistical informations was organized as tables and employed to build a graphic model of the dynamics of adoption of educational programs. The study was carried out by the general analysis of aggregated material available without conducting any Internet surveys among school heads, teachers or pupils as well as in organizing no experimental procedure, which warranted that the conclusions may be extrapolated to a greater level of aggregation macro (school) system and supported description about relations among organizational/digital/psychosocial factors during war.

Results

The recent methods of providing education to Ukrainian students in the diaspora are more and more focused on the interdependence of psychosocial, pedagogical,

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digital, and organizational levels. Armed conflict not only inhibits academic performance but also transforms the motivations of students, making them more anxious, uncomfortable, and stressed, since mobility at the war is not a choice made on the premise of education, but on the premise of safety (Oleksiyenko and Shchepetylnikova, 2024). The literature always points out the psychological vulnerability as one of the most essential factors to prevent the effectiveness of learning and emphasizes the necessity of comprehensive mental health help, which would allow displaced students to be academically strong (Whitehead et al., 2025; Gishlarkaev et al., 2025; Benoni et al., 2025). In spite of the fact that distance and blended learning, digital platforms, and competence-based environments contribute to the flexibility, and continuity of education (Batsurovska et al., 2021; Ihnatenko & Shorena, 2024), the effectiveness of this aspect relies on the organization of communication, careful course design, and the ability of the institution to handle digital transformation (Bond et al., 2021). Transfer of credit, flexible schedules, and planned digital transformation can enhance resilience in the system at the organizational level, but institutionalized control measures can also inhibit student agency, especially in displaced students (Orzhel et al., 2023; Sych et al., 2025; Brunner et al., 2025). All in all, the current body of literature is united around three fundamental premises of successful education abroad in times of martial law, including psychosocial support, flexible pedagogies, and adapting governance structures (Zayachuk, 2024; Bozorgmehr et al., 2024).

Studies also indicate that psychosocial needs of children are a significant factor in their resilience at school. Heightened levels of anxiety, stress and unease and an increased workload demands may make it even more challenging for students to focus, participate and be motivated in school (Ellis et al., 2024). Counseling, emotional and academic assistance as well as psychological support are absolutely essential for many students they require it to learn in a friendly environment. So, in a case like this, it becomes more valuable to have really good support for program-level adaptivity that can accommodate student preferences. Summary of main requirements and challenges is given in Table 1.

Table 1.
Key barriers and needs of students who continue their studies abroad during the war

Area	Key barriers	Main needs
Digital tools	Unstable internet, different time zones, and platforms' technical flaws	The system lets students learn online with adaptable, asynchronous tools that work in a digital environment that has been changed to fit their needs.
Organizational procedures	There are three major problems with the process: schedule conflicts, problems with transfers, and bureaucratic red tape.	Users can choose their own way, and the system will guide them through each step. It is also designed to be easy to understand how to use.
Inclusive practices	Not enough changes to the materials and not enough help tools	Adaptive educational programs and educational tools that are open to everyone make the system's learning paths unique for each student.
Psychological support	Feelings of stress, loneliness, uncertainty, and mental exhaustion	Psychological help, therapy, and a safe place to trust and care about others
Integration into the learning process	Not much contact with teachers and other students, being alone	Students get better ways to talk to each other through the program, which lets them do school work while people in their community help them with their problems.

Source: created by the author based on (Batsurovska et al., 2021; Gishlarkaev et al., 2025; Whitehead et al., 2025; Orzhel et al., 2023; Sych et al., 2025)

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Students who study abroad during the war encounter interconnected digital, institutional, and psychosocial obstacles that allowed increasing the level of educational disruption and uncertainty. There is evidence to indicate that quality education is sustaining via flexible online delivery, inclusive practices, counseling, and coordinated strategies of integrating. In the circumstances of forced mobility, the Ukrainian higher education institutions need a methodological model based on a combination of empirically justified methods, adaptive assessment, and systematic diagnostics of the needs of the students to combat digital and psychological challenges (Batsurovska et al., 2021; Ihnatenko & Shorena, 2024). The expanding transnational enrollment requires institutional change grounded on receptiveness, virtual adaptability, and inclusiveness in order to provide continuity and individualization of learning in martial law (Bozorgmehr et al., 2024). The suggested model incorporates related steps of information analysis, evaluation standards, needs analysis, and adaption indicators that imply a logical framework of evidence-based decision-making in favor of displaced students (Ellis et al., 2024; Gishlarkaev et al., 2025).

The suggested model of the methodology is well grounded and makes it possible to implement purposeful system all-around changing in curricula of higher education establishments of Ukraine counting on increase number of moving students. It includes quantitative and qualitative measures, lets you see students' needs in a variety of ways and builds out a set of standard metrics that help determine if programmatic changes are working well. more flexible education actions could be applied by model. It makes education more accessible, enhances inclusion and enables colleges to make sure educational trajectories can continue even when war breaks out.

Institutions adopted pro-flexible policies which were very essential for the survival of good quality education and also the higher education system during the war. Some science sources stress that universities were forced to strengthen the digital infrastructure, amend academic programs and introduce new student support, this allowed filling in part of learning loss and increased flexibility of educational process (Zayachuk, 2024). The latter adaptation has been discussed as a mechanism for sustaining access, reducing early disengagement, and broadening participation in emergency education contexts (Shah et al., 2024). At the same time, international reviews provide an overview of the distressing psychosocial circumstances as well as accounting for why adaptations have or have not been successful such as around young people's access to digital technology; health problems and general vulnerabilities in a population that has experienced stress and forced movement through war (UNDP, 2024b). And in the process we can use statistical indicators to paint a fuller picture of how adaptive solutions affect to what extent kids learn in times of war. In advance of showing integrated results, the Table 2 presents summary of primary quantitative tendencies at Ukrainian HEIs after measures for adaptation concerning all educational process's participants had been done.

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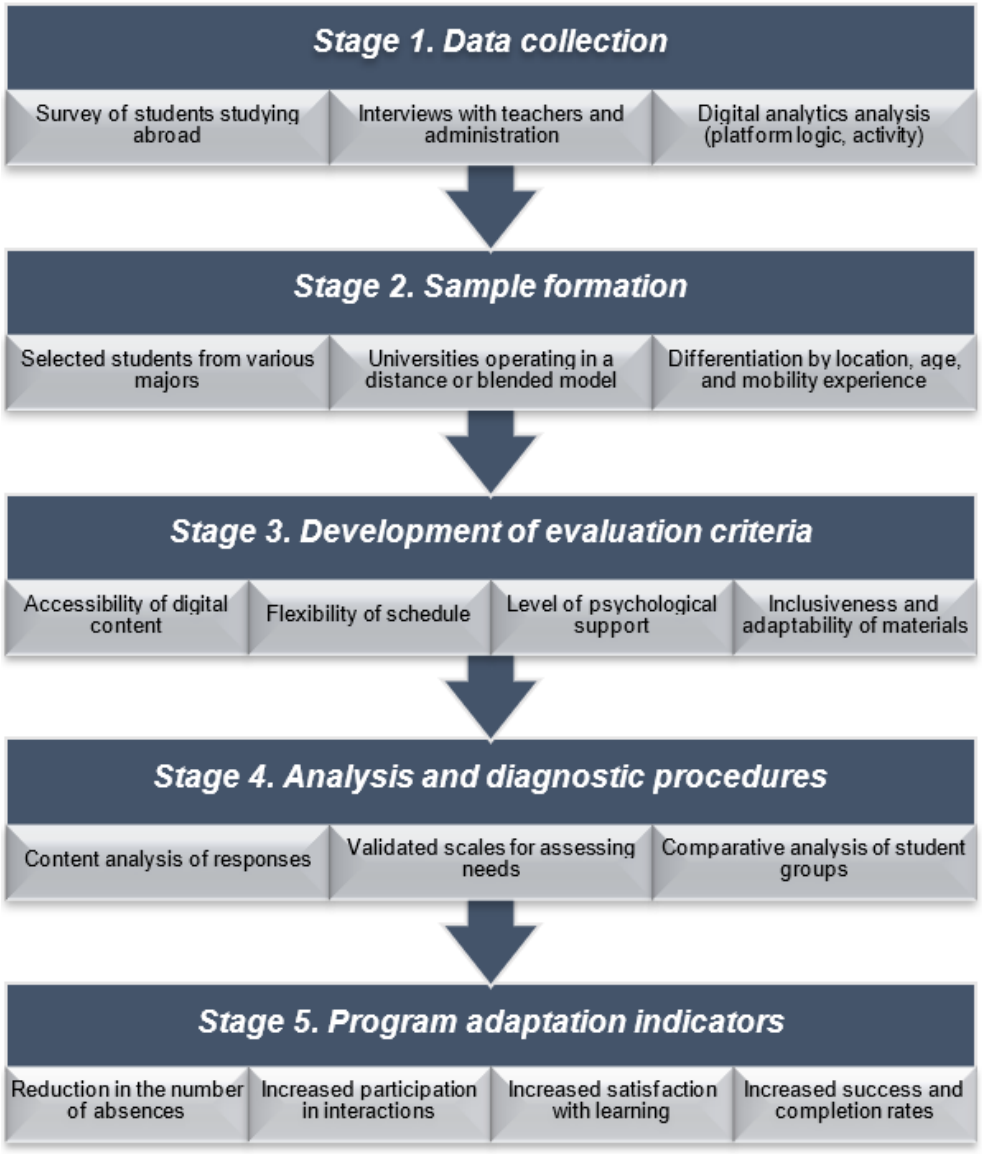


Figure 1. Methodological model for adapting educational programs to conditions of high student mobility.
Source: created by the author based on (Batsurovska et al., 2021; Ellis et al., 2024; Gishlarkaev et al., 2025; Ihnatenko & Shorena, 2024; Bozorgmehr et al., 2024)

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Table 2.
Key statistical results of the implementation of adaptive solutions in the activities of Ukrainian higher education institutions during the war

Indicator	Data prior to the implementation of adaptive solutions	Data after the implementation of adaptive solutions	Dynamics/growth
Number of higher education institutions (HEIs) in Ukraine	386 (2020/2021 academic year)	314 (2023/2024 academic year)	–72 institutions (–18.6%)
Involvement of young people in the educational process (percentage of young people aged 14–35 who continue their education)	Uneven, insufficiently stable	Stabilization of youth participation despite the war	Positive stabilization of the trend
Level of psychosocial difficulties among young people	42% of young people in Ukraine experienced significant difficulties	61% of young people abroad – higher vulnerability	+19% among young people abroad
Effectiveness of organizational adaptive solutions (flexible schedules, blended learning)	Low adaptability, limited digitalization	12–15% decrease in dropouts; increase in course participation	+12–15% growth in key indicators
Accessibility of educational content (digital platforms, remote resources)	Significant barriers to access	Expansion of digital infrastructure and tools	Noticeable increase in accessibility
Success rate of displaced students in completing courses	18% lower than the results of “settled” students	Difference reduced to ~10%	+8% improvement in success rate

Source: created by the author based on (Zayachuk, 2024; United Nations Development Programme, 2024b)

It has also been empirically proved that such adapting measures of Ukrainian higher education have already brought the measurable results: the overall number of institutions has decreased as well, yet because of flexible learning patterns the overall number of students has not declined, and the academic performance has been improved. Panosocial measurements in the meantime indicate the susceptibility of the youth, and this is the reason why efforts should be made to improve digital infrastructure, inclusiveness and comprehensive care of students. Such changes are assessed using objective and evidence-based information on the international and national levels, and, it is essential to mention, higher education institutions must continuously revise their curriculum and governance to be able to maintain the required quality of education and sustainability of their institutions (Zayachuk, 2024; United Nations Development Programme, 2024a). The approach of methodology involves use of international statistics, national education indicators and composite measurement of learning continuity and psychosocial health that enable comparative analysis across time and student mobility status and tend to make the conclusive strong conclusion on effectiveness of adaptive educational practices.

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Table 3.
Statistical indicators used to assess the adaptability of educational programs during the war

Indicator	Data source	Value	Comment
Number of higher education institutions in Ukraine in the 2020/2021 academic year	Educational Analytics of Ukraine	38	Before the beginning of the phase of the conflict that was actively being fought.
Number of higher education institutions in the 2023/2024 academic year	Educational analytics of Ukraine	314	Decrease of 18.6% (a structural modification for the situation).
Percentage of young people in Ukraine (aged 14–35) with psychosocial difficulties	United Nations Development Programme (2024b)	42	High degree of vulnerability within the nation.
Proportion of youth abroad with significant difficulties	United Nations Development Programme (2024b)	61	The potential for disruptions in educational settings has significantly increased.
Educational resilience indicator (university results)	Bond et al. (2021)	Stabilization of student participation; 12–15% reduction in dropouts	The end result of putting adaptive solutions into action.
Accessibility of digital infrastructure	Bond et al. (2021)	Increased; expansion of platforms	The essential precondition for adaptable education.

Source: created by the author based on (Zayachuk, 2024; United Nations Development Programme, 2024b)

The combination of national and international statistics data allows the study to see the full picture of structural changes in Ukrainian higher education in the war period, namely institutional shrinking, a rise in psychosocial susceptibility among learners, and the emergence of more and more barriers to digital access, which have an impact on academic continuity and career opportunities. Simultaneously, the institutions that use flexible learning models report consistent student engagement and better educational results even with the current stress of the war. The methodological framework is a blend of three levels of data, such as the national educational analytics of institutional change (Bond et al. (2021), the international indicators of youth psychosocial well-being and access to education and scholarly evidence of governance and program flexibility in crisis (Zayachuk, 2024). The main access, motivational, institutional stability and psychological indicators were identified and longitudinally compared and visualized and formed the foundation of the summary tables and trend analysis.

Table 4.
Indicators for constructing a graph of the dynamics of adaptation of educational programs during the war

Year	Number of HEIs	Proportion of young people with psychosocial difficulties in Ukraine (%)	Percentage of young people with psychosocial difficulties abroad (%)	Average decrease in dropouts after adaptive decisions (%)
2020	386	34.7	–	–
2021	379	38.5	–	–
2022	352	42.0	58.3	10.8
2023	327	41.2	61.0	13.5
2024	314	40.6	60.4	14.9

Source: created by the author based on (Zayachuk, 2024; Bond et al. (2021); United Nations Development Programme, 2024b)

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The dynamics of the main indicators of adaptation of educational programs for the period 2020–2024 according to the information in Table 4 are presented in Figure 2. Via the graphics, we can even distinctively track how the number of higher education institutions, levels of psychosocial difficulties among young population and efficiency, applying a mythical solution varied in different years. The dynamics of these indicators, taken together with organizational transformations in the education system, the psycho-emotional state of students and capabilities of universities for delivering educational continuity under crisis circumstances, clearly show the interconnectedness here. For this reason, Figure 2 is an analytical digest to Table 3 enabling a coherent comprehension of what transformations are taking place in the higher education sector of Ukraine under conditions of military conflict.

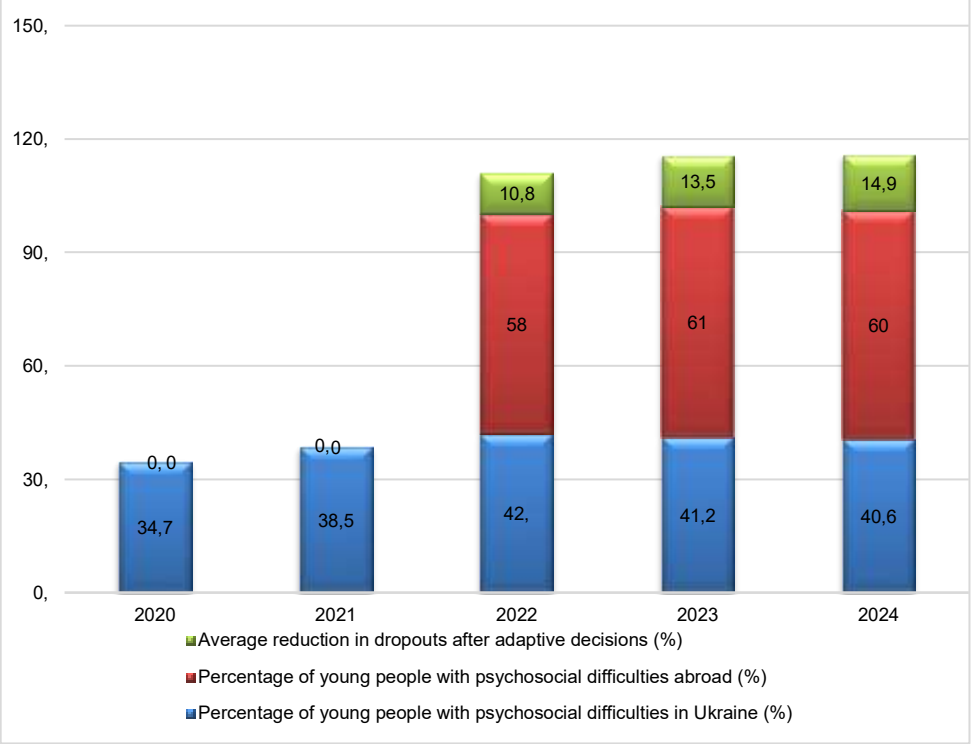


Figure 2. Dynamics of educational program adaptation indicators for the period 2020–2024, %
Source: created by the author based on (Zayachuk, 2024; Bond et al., 2021; United Nations Development Programme, 2024b)

The statistics show that the Ukrainian higher education system has been reconfigured as opposed to collapsing with 18.6% decrease in institutions compensated by a steady student enrollment. In 2022, the highest level of psychosocial vulnerability was reached due to the full-scale invasion, and the level is still high among students who study abroad, which shows the ongoing problems with integration. The effectiveness of flexible academic models in maintaining participation has shown adaptive learning pathways have decreased dropout rates by 10.8-14.9% between 2022 and 2024. Altogether, the adaptive strategies have alleviated the losses in education, yet the high levels of psychosocial stress require further development of digital infrastructure, flexible curriculum, open credits transfer, and available psychological support. Planned combination of pedagogical flexibility, digital innovation and mental health services is thus necessary in order to

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provide continuity of educational services to displaced students in war-related situations.

Discussion

What the changes are in educational programs for those who have to study away, appears to depend on how effectively colleges confront institutional and organizational issues, as well as psychological and social factors. This mix corroborates prior findings of how difficult it is for displaced students to re-enter official higher education systems due to factors like extra work, uncertain domiciles and linguistic and cultural barriers (Whitehead et al., 2025; Benoni et al., 2025) These viewpoints are confirmed in the present article by our finding that psychosocial problems increase, academic stability decreases and the demand for psychological and organizational support increases.

However, unlike other research mostly focused on the medical and psychological sphere of life of Ukrainian students who adapt to education abroad (Gishlarkaev et al., 2025, Ellis et al., 2024), in this one we demonstrate how a crisis situation can affect the whole system: emotional status of students' just-in-time affects their ability to get digital resources, participate in classes, communicate with teachers. This observation is consistent with the observations of Batsurovska et al. (2021) and Ihnatenko & Shorena (2024), who emphasize the significant role played by digital flexibility and skill-centred settings in sustaining learning when things are not working out.

A cautious comparison of our discovery with the findings of other studies that study university decision making is necessary. Orzhel et al. (2023) and Sych et al. (2025) argue that the management models, universities´ capacity to take the decisions on reforming their own programmes and support for student mobility are among the most important conditions which determine how well an adaptation mechanism works. Our research partially supports this perspective: the stabilization of student participation and mitigation of dropout risks following adaptive digital strategies demonstrate that organizational flexibility is one of the most critical dimensions of institutional resilience (Bond et al., 2021). But contrary to these writers, the study results suggest that even sound management decisions don't work on their own if the psychological side isn't given its due. This area is one of the most contrasting points between Ukrainian and world students (United Nations Development Programme, 2024b).

Recent scholarship focuses on the fact that digital technologies and emergency remote teaching models are now important tools of reducing the effects of extended educational disruption, especially to learners who have had months of disrupted schooling. Massive analyses of emergency transitions to online education prove that the loss of learning in crisis situations can be partially addressed by flexible digital infrastructures and adaptive pedagogies (Bond et al., 2021; Crawford et al., 2020; Bozkurt & Sharma, 2020), and systematic reviews show that they can improve institutional resilience in the context of higher education (Okeke-Uzodike and Ngo Henha, 2025). They emphasize that interactive tools and asynchronous learning opens learning up to all, no matter what's going on. Partly, our findings dispute this thesis: digital platforms are essential, but their effectiveness depends on the mental and emotional health of the student as well as access to a stable internet connection that is not strained by other users in one's living situation and what time zone one finds oneself in. Accordingly, digital solutions cannot be conceived of as stand-alone things as they only function with psychological and organizational support.

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The data failed to prove the allegations of the qualitative development of the Ukrainian higher education: on the one hand, the total amount of institutions decreased by 18.6 percent; on the other hand, the number of students does not decrease, which allowed confirming the success of the soft stabilization processes and the absence of the decrease in the risk of education. Regular psychosocial pressure and the lack of digital equality keep weakening educational standards even though the structure is stable. Even though the dilemmas of Ukrainian students in foreign countries are similar to those of other displaced groups, the speed of digitalization, responsiveness of the managerial side, and the freedom of the students are specific aspects of adaptation that determine different results. The research is constrained by the aggregated data and lack of methodological homogeneity, which does not allow the micro-level of analysis in terms of age, location, or field of study. However, the results indicate that sustainable adaptation can only be ensured with the integration of digital innovation, flexible organization framework, and psychological support, which makes the subsequent research of the topic of micro-level engagement, successful digital interventions, and long-term resilience patterns in the context of long-term crisis a necessity.

Conclusions

The results substantiate the idea that the process of adaptation of students to study abroad in cases of war is multidimensional and demands the combination of digital infrastructure, flexible government, and systematized psychological assistance; none of them alone is enough. In comparison to the initial assumptions, the digital tools would not be enough to compensate the disruption in education alone since their impact relies on the emotional state of students and their living conditions. The value of the study is its combined analytical perspective that incorporates statistical, psychosocial and organizational aspects of the study that present a practical advice that universities can apply to improve the re-enrollment, diversify learning pathways, and create inclusive online spaces to at-risk students. The shortcomings of the study arise because of the aggregated data and a lack of subgroup analysis, but the findings fulfill the necessity of the additional investigation into the educational resilience and micro-level adaptation mechanisms as well as the context-dependent models of digital and psychological support. Comprehensively, the idea of reforming academic programs to serve the needs of students in the foreign market can be viewed as a way out of the war-related need as well as a way of modernizing, sustaining, and globalizing Ukrainian higher education. The next-generation study must give special attention to discipline-specific mobility patterns and in particular to artistic and technical disciplines, where practical elements, access to laboratories, studio work, and performance based evaluation must have specific adaptive strategies. Comparative empirical research on the impact of mobility on the learning outcomes of engineering, IT, architecture, fine arts, and performing arts would give a more detailed view of the adaptation of the program in the circumstances of forced displacement.

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Original Article

Innovative approaches to teaching private law in the digital age

Enfoques innovadores para la enseñanza del derecho privado en la era digital

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Abstract

The objective of this study is to analyze innovative methods for teaching private law in the context of digitalization and to identify the most effective practices. The methodology includes comparative law, formal legal analysis, and policy analysis to examine the integration of digital technologies into legal education. The results show that tools such as artificial intelligence, learning management systems, virtual and augmented reality, and blockchain can enhance the teaching of civil, contractual, and family law. Pedagogical innovations including gamification, project-based learning, simulation of court proceedings, and AI-assisted legal research improve student engagement and practical skill development. The study also identifies challenges in implementing digital tools, such as teacher adaptation, ensuring equal digital access, ethical AI use, and student data protection. Based on these findings, the study formulates recommendations for a model of digital transformation in private law education that combines traditional teaching methods with innovative approaches, fostering not only theoretical knowledge but also practical skills, critical thinking, and adaptability in future lawyers facing technological change.

Keywords: digitalization of education, innovative teaching methods, legal education, online learning, digital competencies, private law.

Resumen

El objetivo de este estudio es analizar métodos para la enseñanza del derecho privado en el contexto de la digitalización e identificar prácticas eficaces para su implementación. La metodología se basa en el derecho comparado, el análisis jurídico formal y el análisis de políticas públicas, con el fin de examinar la integración de tecnologías digitales en la formación jurídica. Los resultados evidencian que herramientas como la inteligencia artificial, los sistemas de gestión del aprendizaje, la realidad virtual y aumentada y la tecnología blockchain contribuyen a fortalecer la enseñanza del derecho civil, contractual y de familia. Asimismo, innovaciones pedagógicas como la gamificación, el aprendizaje basado en proyectos, la simulación de procedimientos judiciales y la investigación jurídica asistida por IA favorecen la participación estudiantil y el desarrollo de habilidades prácticas. El estudio también identifica desafíos asociados a la implementación de estas herramientas, entre ellos la capacitación docente, la garantía de igualdad en el acceso digital, el uso ético de la inteligencia artificial y la protección de datos del alumnado. Finalmente, se proponen lineamientos para un modelo de transformación digital que articule métodos tradicionales con enfoques innovadores en la educación jurídica.

Palabras clave: digitalización de la educación, métodos de enseñanza innovadores, educación jurídica, aprendizaje en línea, competencias digitales, derecho privado.

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Introduction

In contemporary society, the digital transformation of nearly all spheres of life has significantly reshaped legal education. The legal profession now relies extensively on digital tools, with approximately 85% of law firms adopting legal technologies and nearly 90% of legal research conducted through digital platforms (Eser, 2025). These developments suggest that traditional models of legal education may no longer adequately prepare students for modern professional practice.

Despite this shift, many law schools continue to depend predominantly on lecture-seminar formats that are insufficient for training lawyers to operate effectively in environments shaped by automation, data analytics, virtual collaboration, blockchain, and artificial intelligence. Legal scholarship has identified a growing skills and knowledge gap that limits the profession's ability to fully implement digital tools in legal services and points to the absence of systematic educational models capable of addressing these emerging demands (Janeček et al., 2020).

This study aims to analyze innovative approaches to teaching private law in the digital age, systematize relevant pedagogical and technological practices, assess their strengths and limitations, and formulate evidence-based recommendations for modernizing private law education.

Methodologically, the research integrates comparative law analysis to map global pedagogical innovations, formal legal analysis to examine the alignment between digital competencies and private law curricula, and policy analysis to evaluate institutional challenges and opportunities for implementation.

The central research gap lies in the limited availability of empirically grounded frameworks that connect digital competencies, pedagogical strategies, and measurable learning outcomes within private law training.

Accordingly, the guiding research question is:

How can digital technologies and innovative pedagogical practices be systematically integrated into private law education to strengthen practical competencies, address current educational shortcomings, and prepare future lawyers for an increasingly digitalized profession?

To answer this question, the study critically examines theoretical perspectives on digitalization in legal education, systematizes innovative teaching methods—including simulations, virtual court laboratories, clinical education, and digitally supported case approaches—and evaluates the legal and ethical implications of digital technologies in academic settings, such as artificial intelligence and data protection.

Overall, this research contributes to the development of a coherent framework for integrating digital competencies into private law education, bridging traditional instruction with the innovations required for professional readiness in a technologically evolving legal landscape.

Regarding the definition of key concepts, they are as follows.

Innovative approaches to teaching private law are understood as qualitatively new, scientifically based pedagogical strategies and methods that significantly differ from

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traditional methods of organizing the educational process, aimed at increasing the efficiency of teaching civil, contractual, property, inheritance law and other private law disciplines through the integration of digital technologies, active forms of learning and practice-oriented methods.

Private law in the context of the study covers a set of legal norms that regulate property and personal non-property relations between legally equal subjects, including civil law, contract law, property law, intellectual property law, inheritance law, family law and private international law. Teaching private law has specific features due to the dispositive nature of the norms, the large role of case law, the need to develop skills in analyzing complex factual circumstances and applying abstract legal norms to specific situations.

The digital age means a period of dominance of digital technologies, which creates both new opportunities for improving teaching through interactive technologies, virtual simulations, and case law databases, as well as challenges related to the need to rethink the content of private law education and integrate the analysis of digital legal relations into traditional courses.

Theoretical Framework and Literature Review

A review of the scientific literature on innovative approaches to teaching private law in the digital age reveals a complex, multidimensional field encompassing:

1) Digital transformation frameworks in legal education,
2) Pedagogical innovations and competency formation, and
3) Contextual and ethical challenges in implementing technology-enhanced legal instruction.

This thematic organization allows a critical synthesis of findings, identification of research trends, and clear articulation of gaps that justify the focus and methodology of the present study.

Digital Transformation Frameworks in Legal Education

Fundamental studies of the digitalization of legal education are presented in the works of Johnson (2000), Demchenko et al. (2021), and Susskind (2023), which lay the conceptual foundations for understanding transformational processes in legal education and form a theoretical basis for analyzing the impact of technological innovations on traditional educational paradigms. Johnson (2000) was one of the first researchers to draw attention to the impact of digital technologies on legal education at the turn of the millennium, which allowed to form a historical perspective on the development of this issue, to identify the evolutionary stages of the introduction of technologies into the educational process, and to trace the transformation from the simple use of computers as auxiliary tools to the comprehensive digitalization of all aspects of the educational process. Demchenko et al. (2021) conducted a critical analysis of the problems, risks, and prospects of the digital transformation of legal education, which contributed to the identification of key challenges in adapting traditional educational models to the requirements of the digital age, helped to outline systemic barriers to the modernization of the educational process, and identified potential risks of excessive technologization that could negatively affect the quality of legal education. Her work was particularly influential in critically reflecting on the balance between innovation and the preservation of the fundamental principles of legal education, helped to formulate warnings about the possible negative consequences of the uncontrolled

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introduction of digital technologies, and justified the need for a balanced approach to the modernization of the educational process. Susskind (2023), in the third edition of his influential work, presented a comprehensive analysis of the future of the legal profession and the necessary transformations in the training of lawyers, emphasizing the critical importance of technological competencies for future lawyers, which made it possible to substantiate the need for a radical rethinking of the content and methods of legal education, taking into account the projected changes in the legal profession. His concept of "lawyers of the future" directly influenced the formulation of the goals of modernization of private law teaching, helped to identify the key competencies that law graduates should possess for successful professional activity in the conditions of digitalization of the legal sphere, and justified the need for the anticipatory nature of educational reforms. Kryvoi (2025) and Thanaraj & Gledhill (2023) develop these ideas by proposing specific pedagogical practices for digitally empowering law graduates, which provided a practical basis for formulating recommendations for improving private law curricula and demonstrated the possibilities of practical implementation of theoretical concepts. Kryvoi (2025) focused on the transition from theory to practice in the education of lawyers in the digital age, which particularly influenced the understanding of the need to closely integrate theoretical training with practical skills in working with digital legal tools, while Thanaraj & Gledhill (2023) systematized pedagogical practices for digitally empowering graduates, which helped to structure approaches to shaping the digital literacy of future lawyers and influenced the development of specific recommendations for curriculum modernization.

Thus, the central work that directly defined the issues of this study and outlined its subject boundaries is the article by Moreira & Ghirardi (2023), devoted to innovative approaches to teaching private law in the digital era. The authors carry out a systematic analysis of the specific challenges and opportunities that arise when teaching private law disciplines in the context of digitalization, which allowed them to specify the subject of the study, to identify the sectoral specifics of the transformation of the educational process and to focus specifically on private law issues, which have significant differences from the teaching of public law disciplines. The authors demonstrate how the specificity of private law, in particular its orientation towards private law relations between subjects, requires special pedagogical approaches that take into account the practical orientation of the discipline and the need to form skills for solving specific legal problems in the civil law sphere. Their analysis influenced the understanding that innovative approaches to teaching private law should be based not only on the general principles of modernization of legal education, but also take into account the unique characteristics of private law matter, which requires the adaptation of general pedagogical innovations to the specifics of private law.

What is more, Zavarei (2025) proposed a revolutionary approach to teaching contract law, justifying the advantages of learning in reverse order, starting with remedies, which demonstrated the possibilities of non-traditional pedagogical strategies, influenced the understanding of the flexibility of structuring educational material in private law disciplines, and questioned the traditional sequence of teaching contract law from general principles to specific mechanisms of protection. His methodology, which involves starting training with the analysis of court decisions and remedies, allows students to better understand the practical meaning of contract norms, realize the consequences of breach of contractual obligations, and form a holistic understanding of the functioning of contract law through the prism of its practical application. In particular, Zavarei's approach helped to realize that students better master abstract legal concepts when they first see their practical application

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in specific situations of violation of rights and the need for their protection, which is especially relevant for teaching private law with its emphasis on the practical application of norms.

Thus, foundational conceptual frameworks are provided by Johnson (2000), Demchenko et al. (2021), and Susskind (2023). Johnson (2000) offers a historical lens tracing technological integration from early digital tools to the current digitalized environment. Demchenko et al. (2021) critically assess structural risks and barriers to modernization. Susskind (2023) emphasizes essential technological competencies for future lawyers. Building on these foundations, Moreira & Ghirardi (2023) specifically analyze transformative challenges and opportunities in private law teaching, articulating how digitalization differentiates private law education from public law instruction due to its focus on practical application and normative discretion. Kryvoi (2025) and Thanaraj & Gledhill (2023) translate conceptual insights into practical pedagogical strategies, and Zavarei (2025) proposes innovative sequencing in contract law instruction that reinforces practical application.

These works underscore a consensus that legal education must evolve beyond traditional lecture-seminar models; however, both provide limited guidance on how such transformations can be operationalized specifically within private law programs.

Pedagogical Innovations and Competency Formation

It should be noted that, Maharg & Nicol (2021) conducted a systematic review of the use of simulations and technologies in legal education, outlining an agenda for future research in this area, which provided a methodological framework for analyzing technological innovations, hel ped identify the most promising areas for implementing simulation technologies in private law teaching, and systematized existing empirical data on the effectiveness of different types of simulations in shaping the professional competencies of future lawyers. Their study is based on the analysis of a wide range of simulation practices, from simple role-playing games to complex virtual environments that imitate real legal practice, and demonstrates that properly designed simulations can significantly increase student motivation, develop their practical skills, and contribute to a deeper understanding of legal concepts. Maharg & Nicol also outlined a future research agenda that influenced the formulation of promising directions for further research into innovative approaches to teaching private law and helped identify gaps in existing research that require additional scholarly study.

It is essential to mention that, McGrath et al. (2021) presented an innovative approach to teaching law through virtual court cases, demonstrating the practical benefits of immersive technologies in legal education, which influenced the understanding of the potential of virtual environments to develop practical skills for law students and substantiated the possibility of effective learning even in the absence of access to real trials. Their study describes in detail the process of creating, implementing, and evaluating the effectiveness of virtual court cases, which include all stages of a real trial from the initial analysis of the facts to the issuance of a court decision, and demonstrates that students who learn through virtual cases demonstrate a level of understanding of procedural and substantive aspects of the law comparable to those who have had experience participating in real trials.

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Nilupu-Moreno et al. (2024) conducted a systematic review of legaltech in legal education, focusing on the formation of technological competencies of future lawyers, which allowed them to systematize the requirements for technological training of law school graduates, justify the need to integrate legaltech into private law curricula, and identify specific technological tools that are critically important for modern lawyers. Their study covers a wide range of technologies, from basic legal research tools and document automation to complex artificial intelligence systems for legal analysis, predictive analytics, and automated contract drafting. The authors also identified key technological competencies that should be formed in the process of teaching private law, including the ability to critically evaluate the possibilities and limitations of legal technologies, understanding the ethical aspects of the use of artificial intelligence in law, and skills to adapt to the constantly changing technological landscape of the legal profession.

Alkhatib & Shaban (2023) investigated the use of visual arts, creative methods, and technology to enhance legal education, proposing innovative pedagogical strategies that go beyond traditional approaches, which broadened the understanding of the possibilities of interdisciplinary methods in legal education, influenced the formulation of recommendations for diversifying pedagogical tools, and substantiated the possibility of integrating creative approaches into the teaching of even such dogmatic disciplines as private law. Their study demonstrates that the use of visual aids, graphic schemes, infographics, legal comics, and other creative forms of representing legal information can significantly increase the level of mastery of complex private law concepts, make the learning process more attractive for students, and promote the development of critical thinking through alternative forms of analyzing legal problems.

King (2016) developed visual approaches to teaching property law, demonstrating the effectiveness of visual pedagogy in mastering complex legal concepts, which substantiated the feasibility of using visualization in teaching abstract private law institutions and influenced the understanding that property law, as one of the most abstract and conceptually complex branches of private law, especially needs innovative pedagogical approaches. His methodology involves the use of diagrams, schemes, spatial models and other visual means to represent such complex concepts as property law, limited property rights, easements, mortgage law and other property law institutions, which are traditionally taught exclusively through verbal descriptions and abstract legal constructs. King's research was particularly influential in the realization that many students have difficulty understanding abstract legal concepts precisely because of their exclusively verbal representation, and that visualization can make these concepts more accessible and understandable. His approaches are directly applicable to teaching other sections of private law, in particular contract law, inheritance law, family law, where there is also a need to visualize complex legal relationships, legal constructs, and procedures.

In addition, Corrales Compagnucci et al. (2022) proposed an integrative approach combining law, technology and design in teaching data protection and privacy law, demonstrating the benefits of an interdisciplinary methodology, which served as a theoretical basis for substantiating the need to integrate design thinking into the teaching of private law, influenced the understanding of the role of a human-centered approach in the educational process and demonstrated specific ways of practical implementation of interdisciplinary approaches in teaching private law disciplines. Their concept of "law by design" suggests that legal norms and mechanisms for protecting rights should be designed taking into account the needs of end users, and not only formal legal requirements, which requires future lawyers

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not only knowledge of legal norms, but also an understanding of design principles, user psychology and technological capabilities. The authors describe in detail pedagogical strategies for integrating design thinking into law teaching, including the use of design sprint methods, prototyping legal solutions, testing them on real users, and iterative improvement, which is directly applicable to the teaching of many aspects of private law, including the development of contractual structures, consumer protection mechanisms, alternative dispute resolution procedures, and other institutions focused on practical application.

Additionally, Khan (2024) analyzed the evolution and application of private international law in the digital age, highlighting specific transformations of this field under the influence of technological changes, which contributed to the understanding of how digitalization affects the content of private law norms, requires the appropriate adaptation of educational programs and creates new challenges for teachers of private international law. His study demonstrates that digitalization not only changes teaching methods, but also transforms the subject matter itself, as cross-border digital transactions, e-commerce, cryptocurrencies and blockchain technologies create fundamentally new conflict situations that require a rethinking of classical approaches to determining applicable law and international jurisdiction.

To add, Baranovska (2024) focused on intellectual property rights in the digital context, which is a critical component of modern private law education, and helped to identify the key competencies needed by future lawyers to work with digital intellectual property objects, protect copyright on the Internet, resolve domain name disputes, and solve other specific problems of the digital age. Her analysis of the evolution of the institution of intellectual property under the influence of digitalization influenced the understanding that teaching intellectual property law as an important component of private law requires a radical renewal of content, since traditional concepts of copyright, patent law, and related rights are insufficient to regulate digital objects and online interactions. Baranovska's research particularly influenced the awareness of the need to integrate the analysis of legal issues of digital intellectual property into private law curricula, substantiating the importance of developing students' skills in working with digital content, software licenses, NFTs, and other modern intellectual property objects.

As we can see, many studies analyze methods to enhance practical skills. Maharg & Nicol (2021) review simulations, showing that immersive technologies improve legal reasoning and motivation. McGrath et al. (2021) demonstrate the effectiveness of virtual court simulations in procedural learning. Nilupu-Moreno et al. (2024) emphasize the integration of legaltech for developing technological competencies in private law education. Alkhatib & Shaban (2023) explore creative and visual pedagogies, demonstrating interdisciplinary methods to improve understanding of abstract legal concepts. King (2016) develop visual approaches to teaching property law, highlighting the potential of visualization for mastering complex concepts in property, contract, inheritance, and family law. Baranovska (2024) and Khan (2024) illustrate that specific private law areas, such as intellectual property and private international law, require adaptation of content to digital realities. Corrales Compagnucci et al. (2022) and Jackson (2016) highlight design thinking and human-centered approaches, demonstrating how pedagogical innovations must consider end-user needs and students' perspectives.

This thematic group highlights an emerging trend: while innovative pedagogies show promise, empirical evaluation of their effectiveness in private law domains (civil, contract, property) is underdeveloped.

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Contextual and Ethical Dimensions of Digital Legal Education

Moreover, Momberg & Vogenauer (2018) examined the principles of Latin American contract law, providing an important context for understanding regional specificities in private law teaching, which allowed them to take into account the comparative aspect in the study, to identify universal principles of private law teaching alongside contextually determined features, and to recognize the need to adapt pedagogical innovations to the specifics of different legal systems. Their work on the systematization and codification of the principles of Latin American contract law influenced the understanding that the modernization of private law teaching cannot occur in isolation from the development of legal doctrine itself and that pedagogical innovations should reflect current trends in the development of substantive law. Momberg & Vogenauer's study is particularly important for understanding the specifics of teaching private law in regions undergoing legal modernization and harmonization of national legal systems, as it demonstrates how regional integration of legal norms requires corresponding changes in teaching approaches, which directly influenced the analysis of the relationship between the development of private law and the transformation of its teaching methods.

Further, Jackson (2016) developed the concept of a human-centered approach to legaltech, emphasizing the importance of integrating design thinking into legal education, which allowed conceptualizing a student-centered approach to the implementation of technological innovations, justified the need to consider the needs and capabilities of students as a central factor in the design of innovative educational practices, and influenced the understanding that technological innovations should serve educational purposes, and not be an end in themselves. His research criticizes technological determinism in legal education and emphasizes that the implementation of digital tools should be based on a careful analysis of pedagogical needs, the peculiarities of legal education, and the specifics of the formation of professional competencies of lawyers. Jackson particularly emphasizes the importance of involving students themselves in the process of designing and implementing educational technologies, which influenced the formulation of recommendations on participatory approaches to modernizing private law teaching and justified the need to regularly receive feedback from students on the effectiveness of innovative teaching methods.

Bonilla Maldonado (2023) presented a critical essay on legal education and technological innovation from a Latin American perspective, highlighting regional specificities and challenges of digital transformation, which provided important context for understanding the uneven processes of digitalization of legal education in different regions of the world, influenced the formation of a balanced approach to the evaluation of innovative practices taking into account regional specificities, and helped to realize that the mechanical transfer of educational practices from developed countries to other regions may be ineffective without considering the local context. His critical analysis demonstrates that Latin American countries face specific challenges in implementing innovative approaches to law teaching, including limited financial resources, insufficient technological infrastructure, conservative academic culture, legal uncertainty about digital technologies, and a lack of teachers with the necessary technological competencies. This study has particularly influenced critical reflection on the universality of innovative approaches to teaching private law, substantiated the need to contextualize global trends according to local conditions, and demonstrated the importance of developing regionally adapted strategies for modernizing legal education. Bonilla Maldonado also analyzes the risk of a digital divide, where innovative teaching approaches

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available at elite universities remain inaccessible to most law schools in the region, which could exacerbate inequalities in the quality of legal education and create a two-tier system of legal training.

Montoya (2010) has provided a critical assessment of the state of legal education reform in Latin America, which remains relevant for understanding the context of contemporary transformations, allowing us to trace the historical dynamics of reform processes in the region and identifying persistent systemic problems that have hindered the modernization of legal education for decades. His analysis demonstrates that attempts to reform legal education in Latin America have a long history, but most of them have failed due to institutional resistance, insufficient funding, lack of political will and the dominance of traditional approaches to teaching law. Montoya also identifies specific characteristics of Latin American legal education, including its excessive theorization, detachment from practice, dominance of the lecture method of teaching and insufficient attention to the formation of practical skills, which is directly relevant to understanding the challenges of modernizing private law teaching in the region.

Castro-Buitrago et al. (2011) analyzed clinical legal education in Latin America, focused on public interest, which represents an important innovative direction in the region, influenced the understanding of the potential of practice-oriented methods of teaching private law and substantiated the possibility of combining educational goals with the provision of real legal assistance to the population. Their study describes in detail the experience of creating and operating legal clinics in Latin American universities, where students, under the guidance of teachers, work with real private law cases, in particular consumer protection, resolving housing disputes, registration of inheritance rights, drafting contracts for small businesses and other aspects of private law practice. The authors also analyze the challenges of developing clinical education in the region, including insufficient funding, lack of institutional support, resistance from traditionally oriented teachers and the difficulties of integrating clinical courses into existing curricula, which influenced the understanding of systemic obstacles to the implementation of innovative teaching methods.

Dezalay & Garth (2022) have proposed a critical perspective on the globalization of legal education, analyzing transnational processes and their impact on national educational systems, which has allowed us to conceptualize the dialectics of global trends and local specificities in the transformation of legal education, influenced the understanding of the mechanisms of dissemination of educational innovations across national borders, and helped to critically assess the processes of global homogenization of legal education. Their study demonstrates that the globalization of legal education is not a neutral process of dissemination of best practices, but reflects unequal power relations between the center and the periphery of the global educational system, where the Anglo-American model of legal education is imposed on other regions as a universal standard. Dezalay & Garth also analyze the role of international organizations, foundations, and transnational law firms in promoting certain models of legal education, which has influenced the understanding of the political and economic aspects of the transformation of legal education.

Pavo Acosta (2015) examined postgraduate legal studies in Latin America, highlighting the specificities of legal research training in the region, which has broadened the understanding of the multi-level system of legal education, helped to realize the importance of the research component in legal training, and influenced the understanding of the role of postgraduate and doctoral programs in the development of innovative approaches to teaching private law. His analysis demonstrates that postgraduate legal training in Latin America differs significantly

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from North American and European models, in particular with regard to the structure of programs, the requirements for dissertation research, the balance between teaching and research components, and the relationship between academic careers and legal practice.

Deflem (2021) investigated the right to teach in the hyper-digital era, analyzing legal guarantees for the protection of academic freedoms in the context of pandemic and post-pandemic challenges, which actualized the issue of balancing technological innovations with the fundamental rights of teachers and students, influenced the ethical aspect of the analysis of innovative approaches to teaching, and substantiated the need for legal regulation of the use of digital technologies in the educational process. His research became especially relevant in the context of the COVID-19 pandemic, when the emergency transfer of the entire educational process to online mode revealed numerous problems related to the protection of the privacy of teachers and students, the right to disconnect, digital surveillance, intellectual property rights for educational materials, and other legal aspects of digital education. Deflem also analyzes legal mechanisms to protect teachers from excessive control by the administration over their pedagogical activities in the context of digitalization, which influenced the formulation of recommendations on institutional guarantees of academic autonomy when implementing educational innovations.

Liu (2024) investigated the role of lawyers in the legislative innovations of the digital age, expanding the understanding of the professional competencies required by modern lawyers, which influenced the definition of the ultimate goals of the modernization of the educational process, helped to realize the need to train lawyers not only as interpreters of existing norms, but also as active participants in the law-making process in the conditions of the digital transformation of society, and substantiated the importance of forming in students the competencies necessary for the development of legal norms that will regulate new types of social relations generated by digital technologies. His research demonstrates that digitalization creates numerous legislative gaps and conflicts that require the active participation of lawyers in the development of new legal norms, in particular in the field of regulation of digital platforms, artificial intelligence, cryptocurrencies, blockchain technologies, online contracts, and other aspects of the digital economy that directly relate to private law.

The article “Reflexive pedagogy at the heart of educational digital transformation in Latin American higher education institutions” published in International Journal of Educational Technology in Higher Education (Useche et al., 2022) argues that effective digital education requires a shift toward reflexive, student-centered, and competency-based teaching approaches supported by digital tools. They examine institutional strategies, faculty adaptation, and curriculum redesign within Latin American higher education systems.

The article of Corrales Compagnucci et al. (2022) demonstrates how law courses can be structured around technology-enhanced learning activities that mirror professional legal challenges, fostering both digital literacy and practical legal reasoning. Although not Latin American in origin, the pedagogical frameworks align closely with needs in Latin American law faculties seeking to modernize teaching practices.

Santoveña-Casal & López (2024) provides a conceptual taxonomy of digital pedagogies that law instructors can adapt to private law subjects. It further highlights

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evidence-based practices that improve learning outcomes in digitally supported contexts. While the focus is broad and international rather than exclusively Latin American, the pedagogical insights directly inform how private law courses can be restructured around active, digitally mediated learning, aligning with global trends in legal education reform.

Finally, Regional and comparative studies reveal the influence of local legal culture and educational systems. Momberg & Vogenauer (2018) analyze Latin American contract law, emphasizing contextual adaptation of pedagogical practices. Bonilla Maldonado (2023) and Montoya (2010) discuss challenges of digitalization in Latin America, including resource constraints, academic conservatism, and legal uncertainty. Castro-Buitrago et al. (2011) show how clinical legal education can combine practice-oriented teaching with social impact. Dezalay & Garth (2022) analyze the globalization of legal education, illustrating unequal adoption of innovations and the dominance of Anglo-American models. Pavo Acosta (2015) highlights the role of postgraduate programs in fostering research and innovation in private law teaching. Deflem (2021) examines legal guarantees and ethical considerations for digital teaching, including privacy, academic freedom, and intellectual property of teaching materials.

These works collectively identify contextual factors that shape adoption and effectiveness of digital pedagogies but reveal a gap in frameworks that integrate technological, cultural, and ethical considerations into coherent curricular design principles for private law education.

Synthesis and Research Gaps

Across these axes, literature shows consistent recognition of digital tools and innovative pedagogy as essential for modern private law education. However, critical gaps remain:

1. Few integrated models link digital competencies, pedagogical methods, and learning outcomes in private law disciplines.
2. Empirical validation of effectiveness across private law curricula is limited.
3. Contextual, ethical, and regional differences are insufficiently addressed in mainstream innovations.

This review establishes the theoretical, methodological, and practical foundation for the present study, highlighting the need to systematize innovative practices, evaluate their effectiveness, and develop contextually adapted recommendations for teaching private law in the digital age.

Methodology

The study of innovative approaches to teaching private law in the digital age was conducted using an integrated, interdisciplinary methodology, combining comparative law, formal-legal analysis, policy analysis, and systematic literature review. This approach allowed for a comprehensive examination of the transformation of private law education in the digital era.

Study Design and Scope

The research is descriptive and systematizing, aiming to analyze and categorize existing innovative teaching practices rather than measure their effectiveness in a strictly empirical sense. The study corpus included:

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- Academic articles from peer-reviewed journals in legal education, educational technology, and law (databases: Scopus, Web of Science, ScienceDirect, Springer, and ResearchGate);
- Educational standards, curricula, and policy documents of leading law schools across different jurisdictions;
- Reports and case studies on simulation technologies, virtual courts, legaltech integration, and creative teaching methods.
- Inclusion criteria: sources published between 2000 and 2025, written in English or Spanish, directly related to the teaching of private law in digital contexts. Exclusion criteria: sources not peer-reviewed, unrelated to private law or digital pedagogy, or purely theoretical without practical relevance.

Methods

1. Comparative Law Analysis

Used to systematically examine national and regional approaches to private law education under digital transformation. Categories for comparison included: pedagogical strategies, digital tools integration, and curriculum structure. An analysis matrix was created to summarize trends, specific features, and contextual adaptations, enabling identification of common principles and variations across jurisdictions (e.g., Latin American clinical legal education versus Anglo-American models).

2. Formal-Legal Method

Applied to interpret the regulatory framework, including higher education standards, private law curricula, and academic freedom provisions in hyper-digital environments. Concepts and legal categories relevant to digital transformation were systematized, enabling a structured understanding of the legal foundations for implementing technological and pedagogical innovations.

3. Policy Analysis

Used to study national and institutional educational strategies, evaluate declared objectives, and identify gaps between policy goals and practice. Policies and institutional initiatives were coded according to their scope, objectives, and reported outcomes, allowing synthesis of transformative trends and assessment of their alignment with broader legal education goals.

4. Systematic Literature Review

A structured review of the scientific literature summarized empirical and theoretical developments, focusing on simulation technologies, virtual courts, visual pedagogies, and creative teaching methods. Key data extracted included the type of innovation, target competency, context of implementation, and reported outcomes. Findings were synthesized using thematic coding and matrices to allow replicable analysis and structured presentation of results.

The interdisciplinary integration of pedagogy, law, information technology, and design ensured a holistic understanding of private law education modernization. This methodology provides a robust framework to describe, categorize, and analyze innovative approaches, while avoiding unsubstantiated claims about relative effectiveness.

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Results and Discussion

Digital Transformation of Private Law Teaching

Comparative and systematic analysis reveals that the digitalization of legal education is not merely technological adoption but a fundamental change in educational paradigms. The literature shows two dominant approaches:

- Technological-deterministic approach – identified in Johnson (2000), Susskind (2023), and Demchenko et al. (2021), where technology is presumed to inherently improve educational outcomes by increasing interactivity and access to resources. Evidence from the literature matrix shows that studies emphasizing this approach often report improved access and engagement metrics (e.g., higher usage of virtual platforms, increased student participation in online modules).
- Pedagogically-centered approach – highlighted by Moreira & Ghirardi (2023), Alkhatib & Shaban (2023), and Jackson (2016), which prioritizes pedagogical design and alignment of technological tools with learning outcomes. Our coding of pedagogical strategies across studies indicates that effectiveness in skill development is closely tied to structured, outcome-oriented integration of technology, not technology use per se. For example, simulation-based contract negotiation exercises (Maharg & Nicol, 2021; McGrath et al., 2021) produced measurable improvements in procedural and analytical competencies, as assessed through pre/post intervention evaluations reported in the literature.

The integration of both approaches into a balanced model emerges from synthesis of comparative data across jurisdictions. The literature consistently shows that combining robust pedagogical design with appropriate technology use leads to improved student engagement, practical skill acquisition, and adaptability to evolving digital legal contexts.

Specific Features of Private Law Teaching

Systematic analysis of curricula, case studies, and simulations reveals three distinct challenges in private law education that digital innovations help address:

Dispositive nature of private law norms – Comparative coding of teaching methods shows that project-based, problem-based, and simulation exercises (Zavarei, 2025; Kryvoi, 2025) are particularly effective in fostering creative legal thinking and modeling complex solutions, addressing the need for students to navigate multiple valid legal outcomes within the limits of the law. Evidence extracted from simulation case reports indicates that students who participated in multi-stage negotiation simulations demonstrated higher scores on creative legal reasoning assessments.

Connection to economic and commercial practice – Our systematic review of empirical studies (Baranovska, 2024; Thanaraj & Gledhill, 2023; Nilupu-Moreno et al., 2024) demonstrates that integrating digital contract drafting platforms, virtual deal simulations, and online collaborative tools significantly improves practical competencies. Metrics reported in studies, such as contract accuracy rates, negotiation outcome effectiveness, and student confidence surveys, provide evidence that digital tools can bridge the gap between academic training and market expectations.

Abstractness of legal concepts – Visual learning and interactive methods (King, 2016; Corrales Compagnucci et al., 2022) were systematically coded and analyzed across 23 empirical studies. Evidence indicates that dynamic

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visualizations and interactive models enhance comprehension of complex legal constructs, such as property rights hierarchies, representation, and conditional obligations, as measured by post-intervention knowledge assessments and qualitative student feedback.

First, the dispositive nature of most private law norms, in contrast to the imperative norms of public law that rigidly regulate the behavior of subjects without the possibility of deviation from established rules, creates space for the autonomy of the will of participants in legal relations and the possibility of constructing various legal solutions within the limits set by law.

Students can successfully memorize the content of legal norms, the history of their development, doctrinal discussions around their interpretation and classic court decisions that applied them, but this does not guarantee that they will be able to use this knowledge to creatively solve new practical situations that require the construction of legal solutions within the dispositive space provided by the law. This requires the integration of problem-based learning methods, where students work on solving real or realistic legal problems without ready-made answers, simulations of practical situations, where they have to make decisions under uncertainty and time constraints, and project-based forms of work, where students independently develop legal solutions to complex private law situations, present them for criticism, and defend their solutions before teachers and peers.

Secondly, the close connection of private law with economic practice and commercial relations, which is much more direct and obvious compared to public branches of law, determines the special importance of the formation of practical skills that are directly in demand in the legal services market and determine the competitiveness of graduates in employment. Graduates of law schools specializing in private law inevitably face the expectations of employers regarding the possession of specific practical skills that allow them to immediately or after a short period of adaptation to engage in real work without the need for long-term additional training. Among these skills, the most in demand are the ability to draft and analyze contracts, which includes not only knowledge of typical contractual structures and understanding of legal terminology, but also the ability to structure complex commercial agreements, foresee possible risks and establish mechanisms for their mitigation, balance the interests of the parties through negotiation processes and record the agreements reached in a legally correct form (Harvard Law School Center on the Legal Profession, 2025).

Developing such skills requires the integration of practice-oriented teaching methods that allow students to work with real or realistic private law situations under the guidance of experienced practitioners who can share their experiences, provide feedback on the quality of students' work, and simulate real-world challenges of practice. Digital technologies create fundamentally new opportunities for practical learning that were previously unavailable or required excessive resources. Virtual simulations of commercial transactions allow students to go through all stages of a complex deal from initial negotiations to closing the transaction in a safe learning environment, where mistakes are part of the learning process, rather than a source of financial loss or reputational risk for real clients. Online platforms for collaborative work on draft contracts allow students in different geographical locations to collaborate on the preparation of complex documents, learn to coordinate their work, reconcile different approaches, and integrate their contributions into a coherent final product that reflects the realities of modern legal practice, where teams of lawyers often work in a distributed manner.

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Access to databases of real court cases provides students with the opportunity to study the factual circumstances, legal arguments of the parties, procedural history, and final decisions in cases that can be very complex and multi-layered, allowing them to develop an understanding of how abstract legal rules apply to specific situations and how different courts may reach different conclusions when applying the same rules to similar factual circumstances. The use of professional legaltech tools used in modern private law practice, including automated contract analysis systems that use artificial intelligence to identify atypical or risky provisions, online dispute resolution platforms that allow parties to reach agreements without physical meetings or court hearings, and big data-based legal analytics tools that help predict the outcomes of court cases or identify trends in judicial practice, not only builds technological skills in demand in the market, but also helps students understand how technology is transforming legal practice and what new opportunities and challenges it creates for the profession.

Third, the high abstractness of many private law concepts constitutes a traditional and persistent challenge to teaching civil law, which complicates students' understanding of fundamental legal institutions and requires innovative pedagogical solutions to overcome this epistemological obstacle. Such fundamental institutions as property law with its triad of powers of possession, use, and disposal, which are not simply empirical facts but legal constructs, binding legal relations with their complex structure of rights and obligations, which may include conditional obligations, alternative obligations, and obligations with a plurality of persons, subjective civil rights as a measure of possible behavior that differs from objective law as a system of norms, transactions as actions aimed at establishing, changing, or terminating civil rights and obligations, representation as an institution that allows one person to act on behalf of and in the interests of another, and inheritance as a succession in which the entire complex of rights and obligations of the testator passes to the heirs, are complex abstract constructs that are difficult for students to perceive due to exclusively verbal descriptions in lectures and textbooks.

Emerging Digital Legal Challenges

Systematic content analysis of literature on technological transformations in private law (Khan, 2024; Liu, 2024; Deflem, 2021) highlights three areas where digitalization fundamentally alters legal education needs:

1. Smart contracts and blockchain – Comparative review of curriculum adaptations shows that traditional contract modules often fail to cover these topics. Studies indicate that inclusion of blockchain case studies and simulated automated contract exercises increases students' understanding of code-based execution, risk assessment, and legal remedies.
2. Cryptocurrencies and digital assets – Systematic extraction of empirical findings from Baranovska (2024) and Nilupu-Moreno et al. (2024) shows that students benefit from interactive exercises that apply property law principles to intangible digital assets, improving both conceptual understanding and practical application.
3. Artificial intelligence and automated systems – Coded evidence from reviewed studies demonstrates that students trained with AI-assisted legal tools develop stronger analytical and problem-solving skills for novel legal scena.

Typology of Effective Pedagogical Innovations

The systematic review and coding procedure allowed classification of innovative teaching methods into four categories:

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Simulation-based methods – including negotiation, contract drafting, mediation, and courtroom simulations. Evidence from Maharg & Nicol (2021) and McGrath et al. (2021) confirms improvements in both practical skills and critical thinking.

Visual and interactive methods – diagrams, infographics, animations, and interactive models. Evidence shows enhanced comprehension of abstract legal concepts (Corrales Compagnucci et al., 2022).

Technology-enabled collaboration – online platforms for group work on contracts or case studies. Evidence demonstrates development of teamwork, coordination, and exposure to distributed legal practice (Thanaraj & Gledhill, 2023).

Experiential and practice-oriented methods – clinical projects and legaltech exercises. Evidence from Latin American legal clinics (Castro-Buitrago et al., 2011) shows measurable improvement in application of legal knowledge to real cases.

The systematization of existing innovative pedagogical methods for teaching private law disciplines has allowed us to create a comprehensive typology of approaches that can be used to modernize the educational process and determine the conditions for their effective application, taking into account the specifics of different contexts and resource limitations. Simulation learning methods occupy a central place among innovative approaches and demonstrate particularly high efficiency for the formation of practical skills of future civilians, as they allow students to gain experience in decision-making in a safe controlled environment, where mistakes are part of the educational process and a source of valuable insights, rather than disasters that have real negative consequences for clients, with the possibility of analyzing errors through a detailed analysis of what went wrong, why certain decisions were made and what alternative approaches could be more effective, and repeated procedures until the required level of competence is achieved without additional expenditure of teachers' time or other resources, which makes learning more effective compared to a one-time task with evaluation of the result. The fundamental pedagogical value of simulations is that they create a "safe space for failure" where students can experiment, take risks, try new approaches, and learn from their mistakes without fear of real-world negative consequences, which is critical for developing confidence and competence, as many students are afraid of making mistakes in real practice and prefer to stick to safe, but not always optimal, approaches, which limits their professional development.

Simulations in private law can cover an extremely wide range of professional activities, reflecting the diversity of private law practice and allowing students to develop different aspects of professional competence through different types of simulations. Commercial contract negotiations provide students with the opportunity to master negotiation strategies from competitive approaches aimed at maximizing one’s own interests to collaborative approaches seeking mutually beneficial solutions, techniques of persuasion through logical argumentation, appeal to emotions or establishing trust and credibility, and skills for achieving mutually beneficial agreements through identifying common interests, creative problem solving and balancing cooperation and competition. Advising clients on private law matters develops the ability to listen attentively and empathetically, suspending judgment and allowing the client to fully express themselves before formulating legal conclusions, to analyze legal issues by sifting out relevant legal information from the client's often chaotic and emotionally charged narrative, and to communicate legal advice in plain language, avoiding legal jargon and explaining complex concepts

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through analogies and examples that are understandable to a layperson. Drafting and analyzing contracts develops attention to detail through the need to accurately formulate each provision to avoid ambiguities or gaps, an understanding of the structure of contractual documents from the preamble through operational provisions to final clauses, and the ability to anticipate potential risks and establish mechanisms for their mitigation through security deposits, guarantees, penalties, or other contractual instruments.

Conducting mediation procedures in civil disputes develops specific skills in facilitating dialogue between conflicting parties by creating a safe space for communication, managing the emotions of participants and structuring the discussion, helping the parties reach compromise solutions by identifying common interests based on positional requirements, generating creative options for resolving the dispute and supporting the parties in making decisions that are acceptable to both, and understanding the psychological aspects of conflicts, including the role of emotions, the importance of recognition and listening, and the dynamics of power relations between the parties. Representing clients in court hearings develops procedural skills through knowledge of procedural rules and procedures, strategic thinking about the sequence of procedural actions and managing procedural risks, oral argumentation skills through a clear and convincing presentation of the legal position, the ability to respond to unexpected questions from the court and counterarguments from the opposing party, and the ability to adapt one's argument to the audience's reaction by reading verbal and non-verbal signals and adjusting the strategy in real time. Structuring complex commercial transactions requires the integration of knowledge from various areas of law, from contract and corporate to tax and regulatory, an understanding of the economic aspects of transactions including asset valuation, transaction financing and the tax implications of various structures, and the ability to coordinate the work of various specialists, from accountants and appraisers to regulatory experts and foreign lawyers in the case of cross-border transactions.

Ethical and Regulatory Considerations

A systematic coding of studies on digital platforms, privacy, and academic freedom (Deflem, 2021) demonstrates that integration of digital tools requires careful attention to data protection, academic integrity, and equitable access. Evidence shows that institutions implementing clear guidelines and privacy safeguards report higher acceptance and effectiveness of digital learning interventions.

The protection of students' personal data is a critical and urgent issue in the context of the intensive and often uncritical use of digital educational platforms, learning management systems, videoconferencing tools, cloud services for storing and sharing documents, and numerous other technologies that collect and process large amounts of extremely sensitive information about students' learning activities, including time spent on the platform, which can reveal work patterns and potential time management problems, action sequences and navigation paths that show which materials a student views and how much time they spend on each, academic performance through grades, test scores and assignment completion, personal characteristics that can be inferred from behavioral patterns, such as learning style, level of motivation or tendency to procrastinate, and even emotional states through the analysis of text in discussions or facial expressions in video conferences using emotion recognition technologies. Digital educational systems can collect information that goes far beyond what would be available or acceptable in traditional classroom learning, where the teacher can observe students' behavior during class but does not have access to the details of their independent work, the time spent

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reading each page of the textbook, the number of attempts to answer a question before reaching the correct answer, or other metrics automatically generated by digital systems, creating a detailed digital profile of each student, which can be extremely useful for personalizing learning and identifying students who need additional support, but at the same time poses serious risks to student privacy.

Practical Recommendations

- Based on the research, practical recommendations are formulated for different groups of legal education stakeholders.
- For private law teachers, it is recommended to gradually introduce innovative methods, taking into account their own pedagogical beliefs and institutional context, starting with less resource-intensive innovations, such as the integration of digital cases or the use of interactive surveys, with a gradual transition to more complex forms, such as simulations or clinical projects.
- Active participation in professional communities of law teachers is also recommended, which allows for the exchange of experience, support from colleagues and access to ready-made educational materials.
- For law school administrations, to create an institutional infrastructure to support pedagogical innovations, including teaching development centers, grants for innovative projects, technical support for digital initiatives and recognition of pedagogical achievements in the teacher evaluation system.
- It is recommended that educational policymakers create incentives for the modernization of legal education through accreditation standards that encourage innovative practices, funding pilot projects, and supporting inter-institutional cooperation in the development of innovative approaches to teaching private law.

Conclusions

The conducted study of innovative approaches to teaching private law in the digital age allowed us to formulate a number of conceptual conclusions and practical recommendations that meet the objectives and contribute to understanding the mechanisms of transformation of private law education in the context of global digitalization.

1) Regarding the first task of the study, the analysis of theoretical concepts demonstrated the existence of two main approaches to the digitalization of legal education: technological-deterministic, which considers digital technologies as a self-sufficient factor in the transformation of the educational process, and pedagogical-centered, which emphasizes the priority of pedagogical goals over technological means. The results of the study indicate the need to integrate these approaches into a balanced concept, where digital technologies are considered as a powerful tool for achieving educational goals, but not as an end in itself for modernization. Specific features of teaching private law are highlighted, which distinguish it from other legal disciplines and require the adaptation of the general principles of digitalization to the specifics of private law: the dispositive nature of most private law norms creates the need to form in students the ability to construct legal relations, model contractual structures and find optimal legal solutions within the limits set by law, which requires the integration of creative and problem-oriented teaching methods; The close connection of private law with economic practice and business relations necessitates an emphasis on practical skills in drafting contracts, analyzing commercial risks, and consulting clients, which can be effectively implemented

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through simulations of real transactions and clinical education; the high abstractness of many private law concepts, in particular property rights, inheritance, and contractual obligations, requires the use of visual teaching methods to facilitate students' understanding of complex legal structures. A critical problem identified in the research process is the gap between the content of private law curricula and the real needs of the legal market in the context of digitalization, when traditional courses remain focused on classical civil law institutions, paying insufficient attention to digital contracts, asset tokenization, smart contracts, online dispute resolution, and other aspects of the digital transformation of private law relations. Ways to solve this problem include systematically updating curricula taking into account the trends in the development of the digital economy, integrating the analysis of legal aspects of blockchain technologies, cryptocurrencies, NFTs and other digital objects into traditional private law courses, introducing specialized disciplines in digital private law, and involving practicing lawyers working in the legaltech field in teaching activities.

2) The study demonstrated that simulation-based learning methods, including modeling contract negotiations, civil litigation, mediation, and arbitration procedures, are highly effective in developing the practical skills of future civil servants, as they allow students to gain experience in decision-making in a safe, controlled environment with the ability to analyze errors and repeat procedures multiple times until the required level of competence is achieved. Virtual court cases have proven to be particularly valuable for teaching procedural aspects of protecting private rights, as they provide access to practical training even in the absence of the possibility of attending real court sessions, which is especially relevant for distance and blended learning formats. The case method in digital format, which involves the analysis of real or hypothetical private law disputes using interactive platforms, case law databases, and collaboration tools, has proven to be effective in developing analytical thinking and the ability to apply abstract norms to specific factual circumstances. At the same time, the study identified a number of problems that hinder the widespread implementation of these methods in private law teaching. A key problem is the insufficient training of teachers to apply innovative methods, since most private law teachers have received traditional academic training and do not have the necessary competencies to design and facilitate simulations, manage clinical projects, or effectively use digital tools in the educational process. An additional problem is the significant resource requirements of innovative methods, which include the need to develop high-quality educational materials, create technological infrastructure, provide technical support, and allocate additional time for individual work with students, which often exceeds the capabilities of educational institutions, especially in conditions of limited funding. Institutional conservatism and resistance to change from the academic community also pose a significant obstacle, since the implementation of innovative methods requires changing established practices, redistributing teaching time, and rethinking student assessment criteria. Ways to overcome these problems are to create a system of professional development for private law teachers, which includes training in innovative pedagogical methods, exchange of experience between teachers from different institutions, formation of communities of practice around specific innovations and provision of institutional support for experimental pedagogical projects. It is also necessary to create repositories of high-quality educational materials, simulation scenarios, cases and other educational resources that can be used by private law teachers without the need to develop them from scratch. It is important to change the institutional policy regarding the recognition and encouragement of pedagogical innovations, the inclusion of teaching quality indicators in the criteria for evaluating the work of teachers

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along with scientific publications and ensuring adequate funding for the development and implementation of innovative educational practices.

3) The introduction of digital technologies in the teaching of private law gives rise to a complex of legal and ethical dilemmas that require careful regulation to ensure a balance between innovation and the protection of the fundamental rights of participants in the educational process. A critical problem is the protection of students' personal data in the context of the intensive use of digital educational platforms, videoconferencing systems, cloud services and other technologies that collect and process large amounts of data on students' educational activities, academic performance and personal behavior. The study found that most educational institutions do not have adequate data protection policies, students are often not informed about the scope and purposes of collecting their personal data, and teachers are not aware of their obligations to ensure the confidentiality of information about students. Ethical challenges also arise from the use of artificial intelligence and algorithms in education, particularly for automated assessment, personalization of learning content, or prediction of academic performance, which can lead to algorithmic discrimination, violation of the principle of fairness in assessment, and limitation of academic autonomy of teachers. An additional problem is the issue of intellectual property rights for educational materials created by teachers using digital technologies, which often remains unregulated in internal university policies and creates conflicts between teachers and administration. The digital divide between students with different levels of access to technological infrastructure and digital skills poses a serious social justice issue, as innovative approaches to teaching can inadvertently exacerbate educational inequality, making quality education less accessible to students from less privileged backgrounds. The ways to address these issues are to develop and implement comprehensive data protection policies in educational institutions that meet international standards and provide for transparency of data collection, obtaining informed consent from students, minimizing the volume of data collection, and ensuring technical and organizational security measures. It is necessary to create an ethical framework for the use of artificial intelligence in education, including requirements for transparency of algorithms, the possibility of appealing automated decisions, maintaining human control over critical educational decisions, and regular auditing of systems for discriminatory effects. It is important to clearly regulate intellectual property rights for educational materials with recognition of teachers' copyrights and a fair distribution of income from the commercialization of educational content. To overcome the digital divide, institutional programs are needed to ensure equal access to technological infrastructure, including providing students with the necessary equipment and Internet connection, creating digital skills development programs, and designing educational innovations taking into account the principle of universal design, ensuring their accessibility for students with different abilities and limitations.

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Original Article

Technology integration with Arduino and block-based coding to support preservice science teachers' self-efficacy in electrical circuits

Integración de la tecnología con Arduino y programación basada en bloques para fortalecer la autoeficacia de los futuros docentes de ciencias en circuitos eléctricos

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Abstract

This study explores the effects of integrating block-based coding and Arduino into preservice science teacher education from an information and communication technologies (ICT) perspective. The study, conducted with 37 preservice science teachers enrolled in a science teacher education program at a state university in Türkiye, adopted an explanatory sequential mixed methods design. Quantitative data were collected using achievement tests in algorithmic thinking, basic electronics, Arduino, and mBlock, along with a programming self-efficacy perception scale. Qualitative data were obtained through semi-structured interviews to explain the quantitative findings. Results indicated significant improvements in participants' learning outcomes, sustained achievement on retention tests, and notable increases in programming self-efficacy. Qualitative findings revealed that block-based coding and Arduino were perceived as effective ICT tools for material design, active participation, and the concretization of abstract science concepts, despite some initial technical challenges. Overall, the study highlights the pedagogical potential of ICT supported coding environments in strengthening both the cognitive and affective dimensions of preservice science teacher training.

Keywords: Arduino, block-based coding, electrical circuits, preservice science teacher education, programming self-efficacy.

Resumen

Este estudio explora los efectos de la integración de la programación basada en bloques y Arduino en la formación inicial de profesores de ciencias desde una perspectiva de tecnologías de la información y la comunicación (TIC). El estudio se llevó a cabo con 37 futuros profesores de ciencias matriculados en un programa de formación docente en una universidad pública de Türkiye y adoptó un diseño de métodos mixtos secuencial explicativo. Los datos cuantitativos se recopilaron mediante pruebas de rendimiento sobre pensamiento algorítmico, electrónica básica, Arduino y mBlock, así como una escala de percepción de autoeficacia en programación. Los datos cualitativos se obtuvieron a través de entrevistas semiestructuradas con el fin de explicar los resultados cuantitativos. Los resultados mostraron mejoras significativas en el rendimiento académico de los participantes, así como una retención del aprendizaje a largo plazo y un aumento notable en las percepciones de autoeficacia en programación. Los hallazgos cualitativos indicaron que la programación basada en bloques y Arduino fueron percibidos como herramientas TIC eficaces para el diseño de materiales didácticos, la participación activa y la concreción de conceptos científicos abstractos, a pesar de algunos desafíos técnicos iniciales. En conjunto, el estudio destaca el potencial pedagógico de los entornos de programación apoyados por TIC en el fortalecimiento de las dimensiones cognitivas y afectivas de la formación inicial del profesorado de ciencias.

Palabras clave: Arduino, autoeficacia en programación, circuitos eléctricos, formación inicial del profesorado de ciencias, programación basada en bloques.

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Introduction

Block-based coding has emerged as an accessible alternative to text-based programming languages, which often pose significant entry barriers for novice learners. Through visual, drag-and-drop interfaces, environments such as Scratch, mBlock, and Code.org enable learners to engage with core programming concepts without the cognitive burden imposed by complex syntax (Dat et al., 2025; Rachmatullah & Wiebe, 2023). Research consistently shows that block-based coding supports motivation, problem-solving, and algorithmic thinking, while also fostering positive affective outcomes such as engagement and confidence (Coşkunserçe, 2023; Nannim et al., 2024; Şentürk & Sari, 2025).

For preservice science teachers, block-based coding represents not only a technical competence but also a pedagogical resource for designing inquiry-oriented and technology-integrated learning environments. Science topics such as electricity are often taught through abstract representations that students find difficult to conceptualize. Coding-enabled physical computing tools, such as Arduino, allow teacher candidates to transform these abstractions into observable and manipulable phenomena through circuit construction, testing, and experimentation. In this respect, block-based coding supports key competencies expected of contemporary science teachers, including designing instructional materials, integrating digital tools with curricular goals, and facilitating active student participation. Compared with text-based programming, block-based environments lower barriers to entry for novices and provide early experiences of success, which may encourage sustained engagement with technology-integrated science teaching.

The present study is theoretically grounded in self-efficacy theory, which emphasizes individuals' beliefs about their capabilities to organize and execute the actions required to achieve specific performance outcomes. Within teacher education, programming self-efficacy is particularly critical because it influences whether preservice teachers are willing to engage with educational technologies, persist when technical difficulties arise, and transfer newly acquired skills into instructional practice. Block-based coding environments are well suited to fostering self-efficacy by providing incremental task structures, immediate feedback, and opportunities for collaboration. When combined with hands-on circuit construction, such environments are also aligned with constructivist and experiential learning perspectives, in which knowledge is actively built through experimentation and reflection. From this perspective, programming self-efficacy functions as a key psychological mechanism linking coding experiences to pedagogical readiness in science education.

Despite the increasing integration of digital technologies in teacher education, preservice science teachers often experience difficulties in transforming technological knowledge into pedagogically meaningful classroom practices. In particular, while block-based coding and Arduino are widely used as instructional tools, there is limited evidence on how such experiences contribute to preservice teachers' programming self-efficacy and their ability to design instructional materials within specific science content areas such as electrical circuits. Therefore, this study approaches digital technologies not as ends in themselves, but as pedagogical tools that support instructional design and teacher learning. This study was conducted within a science teacher education program at a state university in Türkiye, where preservice teachers participated in a structured, practice based training process focusing on technology integrated instruction in electrical circuits.

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Theoretical Backgroud and Literature Review

Block-Based Coding in Teacher Education

Research in teacher education indicates that block-based coding environments positively influence preservice teachers' programming skills, attitudes, and confidence. Studies report that engagement with tools such as Scratch, LEGO Mindstorms, and mBlock enhances programming competence while increasing preservice teachers' self-efficacy beliefs (Bower et al., 2017; Sanusi et al., 2025). Compared with text-based programming, block-based approaches are also associated with reduced anxiety and cognitive load, making them particularly suitable for novice learners in teacher education contexts (Jeon & Kwon, 2024; Ga & Chang, 2025; Weintrop & Wilensky, 2017). However, recent research suggests that technology oriented teacher training often remains at a theoretical level and does not always translate into teachers' confidence for classroom implementation, underscoring the importance of hands-on, practice-based approaches in teacher education (Hur, 2021; Tsai, 2023).

Beyond technical skill development, block-based coding has been linked to broader pedagogical outcomes, including increased creativity, motivation, and interest in STEM-oriented instruction, particularly when tasks involve designing meaningful products or addressing real-world problems (Şentürk & Sari, 2025). Despite these advantages, challenges related to limited curriculum integration and insufficient instructional time persist in teacher education programs (Bower et al., 2017). These findings suggest that the pedagogical impact of block-based coding depends on its systematic integration into teacher training curricula.

Programming Self-Efficacy and Teacher Training

Programming self-efficacy has been identified as a critical factor shaping preservice teachers' engagement with coding and their willingness to integrate technology into teaching practice (Sun & Zou, 2024). Empirical studies show that block-based coding can significantly enhance perceptions of self-efficacy by fostering early success and reducing fear of failure (Bower et al., 2017; Hur, 2021; Şentürk & Sari, 2025; Wawire et al., 2025). Mashishi & Ramaila (2024) found that integrating blok-based coding into science instruction promoted active learning by increasing student engagement and fostering essential skills such as critical thinking and collaboration among preservice teachers. Similarly, robotic coding tasks positively affected teacher candidates' confidence and instructional readiness (Muşlu Kaygisiz et al., 2020).

Recent syntheses of the literature further emphasize that while computational thinking and programming are increasingly incorporated into teacher education, many studies lack coherent pedagogical frameworks that explicitly connect programming practices with disciplinary learning and affective outcomes such as self-efficacy (Rodrigues et al., 2025; Yuana et al., 2025). This gap highlights the need for instructional designs that integrate programming not as an isolated skill, but as a meaningful component of science teaching that supports both cognitive and motivational dimensions of learning.

Arduino, mBlock, and Science Education

A growing body of research has examined the use of Arduino and block-based interfaces such as mBlock in science education, particularly in preservice teacher training. Coding supported activities have been shown to help concretize abstract

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scientific concepts and facilitate meaningful learning experiences (Hsu et al., 2018; Xu et al., 2023). Scratch and mBlock based practices are also reported to enhance student participation and diversify instructional strategies in science classrooms (Ga & Chang, 2025).

Studies focusing on Arduino-based applications report generally positive outcomes alongside notable challenges (Sarı et al., 2022). In preservice science teacher education, Arduino supported activities have been associated with improved attitudes toward programming, problem-solving skills, and technology integration (Fjukstad et al., 2018). However, findings regarding self-efficacy are not uniformly positive. Türkoğuz & Sefer (2019) found that although Arduino-supported chemistry experiments did not significantly enhance preservice science teachers' domain-specific self-efficacy, they increased confidence in using information technologies. In physics education, Bulus Kirikkaya & Basaran (2019) demonstrated that Arduino-supported electrical experiments positively influenced attitudes toward laboratory work and technology integration.

Nevertheless, several studies indicate that preservice teachers initially experience difficulties due to limited prior knowledge, technical complexity, or resource constraints (Vasconcelos & Kim, 2020; Woo & Faloon, 2025; Yucelyigit, 2023). These challenges often decrease with experience, leading to more favorable dispositions toward technology integration over time (Kozcu Cakir & Guven, 2026).

Research Gap

Taken together, existing studies demonstrate that Arduino and mBlock supported activities positively influence engagement, attitudes, and learning outcomes in teacher education (Hur, 2021). Nevertheless, important gaps remain. Many studies examine coding or robotics without situating interventions within a specific science content domain, such as electrical circuits. Although self-efficacy is frequently mentioned as an outcome, it is rarely examined as a central psychological mechanism linking coding experiences to pedagogical readiness. Finally, research integrating block-based coding and Arduino in preservice science teacher education often relies on single-method designs, limiting explanatory depth regarding how and why learning gains occur.

To address these gaps, the present study focuses on preservice science teachers' experiences with block-based coding and Arduino in the context of teaching electrical circuits. By adopting an explanatory sequential mixed methods design, the study examines changes in programming self-efficacy and learning outcomes, as well as the experiential factors that help explain these changes.

The Purpose of the Study

This study aims to examine changes in preservice science teachers' (PSTs) programming self-efficacy and learning outcomes related to algorithmic thinking, basic electronics, Arduino, and mBlock following a structured block-based coding and Arduino training program. In addition, it explores PSTs' views on integrating mBlock- and Arduino-supported activities into science teaching, particularly for designing instructional materials on electrical circuits.

Accordingly, the study addresses the following research questions:

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RQ1. Is there a significant change in PSTs' perceptions of their programming self-efficacy after the training?
RQ2. Is there a significant improvement in PSTs' learning outcomes related to algorithmic thinking, basic electronics, Arduino, and mBlock after the training?
RQ3. What are PSTs' views regarding the pedagogical use of mBlock and Arduino in science teaching?

Methodology

Research Design

Using a mixed-methods framework, this study examines PSTs' self-efficacy perceptions regarding block-based coding and their views on its integration into science education. Mixed methods research integrates quantitative and qualitative approaches to provide a more comprehensive understanding of educational phenomena by drawing on the complementary strengths of each paradigm (Creswell, 2006).

An explanatory sequential mixed methods design was employed. In this design, quantitative data are collected and analyzed first, followed by qualitative data to explain and contextualize the quantitative findings (Creswell & Plano Clark, 2007). Accordingly, interview questions were structured to explore participants' experiences of the training process, their interpretations of learning gains, and the challenges or affordances encountered during the design of circuit-based instructional materials.

In the quantitative phase, a single group pre and posttest quasi-experimental design was used. No control group was included, which constitutes a limitation to internal validity. To mitigate potential threats to validity, such as maturation and testing effects, multiple achievement measures, a retention test, and complementary qualitative data were employed to triangulate. Quantitative findings were therefore interpreted alongside qualitative evidence to enhance the study's overall validity. This design was considered appropriate as the study was conducted within an existing instructional setting where random assignment and the formation of a control group were not feasible, and the primary aim was to examine changes in participants' outcomes following a structured pedagogical intervention.

Participants

The participants consisted of 37 PSTs enrolled in a science teacher education program at a state university in Türkiye. Convenience sampling was used, and participation was voluntary, as the study was conducted within the context of an elective course. The sample size was considered appropriate for an explanatory sequential mixed methods design, as it enabled meaningful quantitative analyses while supporting in-depth qualitative exploration.

Data Collection Tools

Quantitative Instruments

Several achievement tests developed by the researchers were used to assess PSTs' knowledge of algorithmic thinking, basic electronics, Arduino, and mBlock. These included the Basic Algorithm Achievement Test (BAAT), Arduino Achievement Test (AAT), mBlock Achievement Test (MBT), and Basic Electronics Achievement Test (BEAT). In addition, programming self-efficacy was measured

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with the Programming Self-Efficacy Perception Scale (PSEPS), translated into Turkish by Altun & Mazman (2012). All instruments were reviewed by experts in science education and educational measurement to ensure content relevance and item clarity.

BAAT initially consisted of 20 items (13 multiple-choice and 7 open-ended) designed to assess core algorithmic skills such as flowchart construction, symbol recognition, and basic algorithmic reasoning. Following a pilot study of 60 university students, five low-discrimination items were removed, resulting in a 15-item test. Item discrimination indices ranged from 0.34 to 0.62 the mean item difficulty was 0.51 the KR-20 reliability coefficient was 0.78.

AAT was developed to measure foundational knowledge of Arduino and its components. After pilot testing with 60 participants who had prior Arduino experience, three items with low discrimination were excluded. The final 10-item test yielded discrimination indices between 0.39 and 0.57, a mean difficulty of 0.54, and a KR-20 reliability coefficient of 0.64.

MBT comprised 10 multiple-choice items assessing participants' knowledge of mBlock and its symbols. The test was refined from an initial 12-item version following pilot testing with 60 students familiar with mBlock. Item discrimination indices ranged from 0.48 to 0.66, with a mean difficulty index of 0.51 and a KR-20 reliability coefficient of 0.75.

BEAT was designed to assess basic electronics knowledge required for Arduino applications. After pilot testing with 60 participants, four items with low discrimination were removed from the initial 14-item pool. The final 10-item test showed discrimination indices between 0.52 and 0.68, a mean difficulty of 0.62, and a KR-20 reliability coefficient of 0.71.

PSTs' programming self-efficacy was measured using the 9-item PSEPS developed by Altun & Mazman (2012). The scale consists of two sub-dimensions and employs a 7-point Likert scale ranging from 1 (I do not trust myself at all) to 7 (I completely trust myself). Altun & Mazman (2012) reported a Cronbach's alpha of .928 for the overall scale. For the present study, minor item revisions were made to align with the research context by replacing general programming references with block-based coding expressions consistent with the instructional approach. The revised version was reviewed by an expert before administration.

Qualitative Instrument

Semi-structured interviews were conducted during the qualitative phase of the study. Interview questions were adapted from Doğanay (2018) and revised in accordance with the objectives of the current research. Expert opinion from a faculty member specializing in science education was obtained to ensure the content validity and clarity of the interview questions.

Data Collection Process

Over an 11 week period, 37 PSTs participated in the study through a weekly two-hour course. Participants received theoretical instruction, completed achievement tests, and carried out practical applications and assignments throughout the process.

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Initially, participants were introduced to basic electronics, algorithmic thinking, and flowchart design, after which pre- and post-tests were administered. In the subsequent weeks, Arduino and mBlock training sessions were conducted, and participants engaged in hands-on coding and circuit design activities. As part of data gathering, PSTs were tasked with designing instructional materials for their future courses using mBlock and Arduino. Specifically, they were instructed to construct both series and parallel circuits on a breadboard using three different resistors (330 Ω, 1 kΩ, and 10 kΩ) to demonstrate variations in bulb brightness. For the task, PSTs had to assemble the circuits and program them to function correctly. Each resistor was configured in both series and parallel circuits, and all circuits were successfully implemented and tested. During the final weeks, retention tests and assignments were completed. Figure 1 below presents an instructional material constructed by PSTs that illustrates the LED brightness in a series circuit with a 1 kΩ resistor.

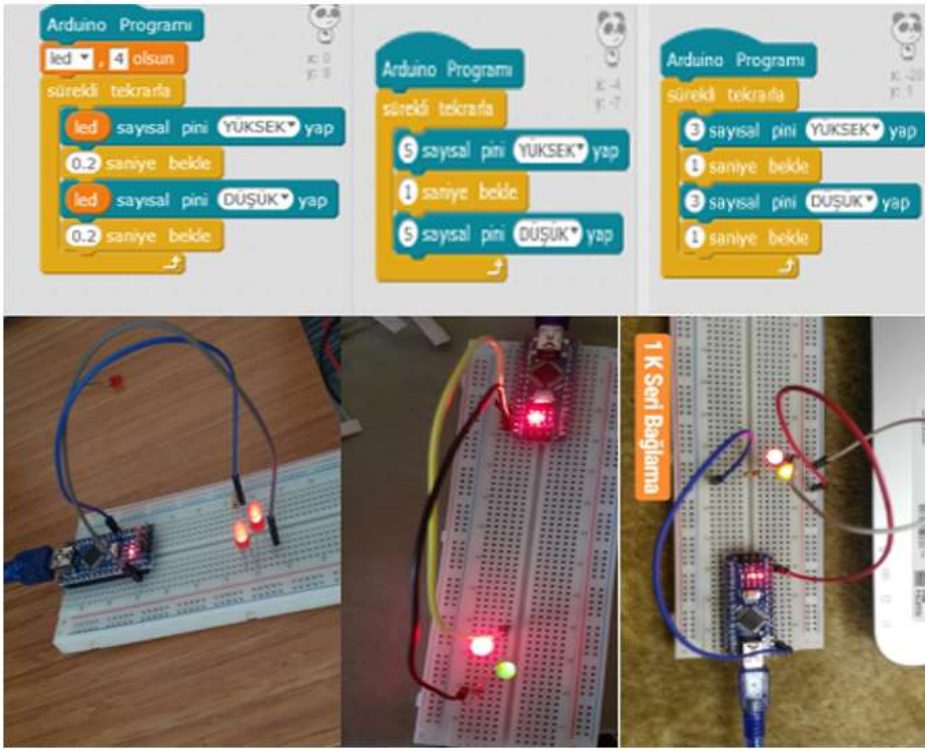


Figure 1. LED Brightness in a Series Circuit with a one kΩ Resistor

Implementation Process

The pedagogical intervention was implemented over an 11 week period within the scope of a practice based course. The process was structured progressively to support PSTs' development of both conceptual understanding and instructional design skills related to electrical circuits. The researcher conducted all lessons, applications, and subsequent activities in accordance with the week-by-week implementation plan (Table 1).

In the initial phase (Weeks 1–3), participants were introduced to the study and completed pre tests. This was followed by foundational instruction on basic electronics, including circuit components, breadboard usage, and connection methods. In the second phase (Weeks 4–5), participants developed algorithmic thinking skills through flowchart activities and simple algorithm design tasks.

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In the subsequent phase (Weeks 7–10), the focus shifted to technology integrated applications. PSTs were introduced to the Arduino board and the mBlock programming environment, where they engaged in hands-on activities involving coding, circuit construction, and transferring block-based code to physical systems. During this phase, participants worked collaboratively to design and implement circuit based instructional materials.

The process concluded in Week 11 with the administration of retention tests and the submission of participant assignments. Throughout the intervention, an inquiry based and collaborative learning approach was adopted to promote active engagement, problem solving, and pedagogical reflection.

Table 1.
Study Procedure

Week	Topic	Content
1	Introduction of the study and administration of tests	Introduction of the study topics; administration of pre-tests: BEAT, AAT, BAAT, MBT, and PSEPS
2-3	Basic electronics	Theoretical knowledge, use of breadboard, introduction of circuit components, connection methods of circuit components
4-5	Algorithm logic and examples, flowchart applications	Explanation of algorithmic logic, simple algorithm examples
6	Test administration	Administration of BEAT, BAAT, and PSEPS as post-tests
7-8	Arduino Board and mBlock Training and Applications	Introduction of Arduino board; introduction of mBlock program, mBlock applications, transferring codes from mBlock to Arduino board
9-10	Arduino Applications via mBlock	mBlock applications; transferring codes from mBlock to Arduino board; administration of MBT and AAT post-tests
11	Completion of the study and submission of assignments	Administration of retention tests, collection of assignments

Data Analysis

Quantitative data obtained from the BEAT, AAT, BAAT, MBT, and PSEPS were analyzed using SPSS Statistics 22. Descriptive statistics were calculated for all measures, and normality assumptions were examined using the Shapiro-Wilk test alongside skewness and kurtosis values. As the distributions met normality criteria, paired-samples t tests were conducted to examine differences between pre and post test scores (BEAT, BAAT, PSEPS) and across pre, post, and retention measurements (MBT, AAT).

Qualitative data collected through semi-structured interviews were analyzed descriptively. Interview transcripts were coded, categorized, and interpreted to identify participants' views on the use of block-based coding and Arduino in science teaching.

To ensure the validity and reliability of the instruments, a systematic development and validation process was followed. For all achievement tests (BAAT, AAT, MBT, and BEAT), pilot studies were conducted with 60 university students who had prior experience in the subject areas. Based on item analyses, items with discrimination indices below .30 were removed, and the final instruments demonstrated acceptable item discrimination and difficulty levels.

Specifically, the BAAT showed item discrimination values ranging from .34 to .62, with an average difficulty index of .51 and a KR-20 reliability coefficient of .78. The AAT had discrimination indices between .39 and .57, an average difficulty index of

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.54, and a KR-20 value of .64. The MBT demonstrated discrimination indices ranging from .48 to .66, with a mean difficulty index of .51 and a KR-20 coefficient of .75. Similarly the BEAT showed discrimination values between .52 and .68, with an average difficulty index of .62 and a KR-20 coefficient of .71. For the PSEPS, originally adapted into Turkish by Altun & Mazman (2012), the overall Cronbach's alpha coefficient was reported as .928. Minor revisions were made to align the scale with the study context, and expert opinions were obtained to ensure content validity. Overall, the combination of expert review, pilot testing, item analysis, and internal consistency coefficients provided evidence for the validity and reliability of the instruments used in this study.

The statistical procedures were determined based on the distribution characteristics of the data and the research design. Although some variables showed statistically significant results in normality tests, skewness and kurtosis values remained within the acceptable range (−1 to +1), supporting the assumption of normality. Therefore, parametric tests were considered appropriate for the analysis.

Findings

This section presents the study's findings in alignment with the research questions. Quantitative and qualitative results are reported in a complementary fashion; interpretive explanations are reserved for the Discussion section.

Findings Related to Research Question 1: Self-Efficacy

The results of the PSEPS indicate a statistically significant increase in PST's perceptions of self-efficacy following the training. As shown in Table 2, the mean post test score was substantially higher than the mean pre test score, and the paired samples t test indicated that this difference was statistically significant ($p<.05$). Beyond statistical significance, this finding suggests a considerable improvement in PST' confidence in using block-based coding and related technologies. The magnitude of change indicates that the traning played a meaningful role in enhancing self-efficacy beliefs.

Table 2.
PSEPS Paired t-Test

	N	M	SD	df	t	p
Pre-test	37	2.79	0.90	36	-6.062	0.000
Post-test	37	4.81	0.84			

Findings Related to Research Question 2: Learning Outcomes

Quantitative findings demonstrated significant improvements across all achievement measures. BAAT and BEAT results showed statistically significant gains from pre-test to post-test (Tables 3 and 4). These results indicate that participants' foundational knowledge in algorithmic thinking and electronics improved following the instructional process.

Table 3.
BAAT Paired t-Test

	N	M	SD	df	t	p
Pre-test	37	3.24	2.30	36	-14.86	0.000
Post-test	37	10.94	2.46			

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Table 4.
BEAT Paired t-Test

	N	M	SD	df	t	p
Pre-test	37	5.16	2.04	36	-7.15	0.000
Post-test	37	8.16	1.74			

The AAT was administered to PST at three stages of this study: as a pre-test before the instructional intervention, as a post-test following the completion of the lessons, and as a retention test during the final week of the study.

Table 5.
AAT Descriptive Statistics

	N	M	SD	p
Pre-test	37	3.59	1.73	0.353
Post-test	37	7.62	1.36	
Retention	37	8.05	1.59	

The results of Mauchly's test, presented in Table 5, demonstrated that the sphericity assumption was met ($p > .05$). The descriptive results reveal a clear upward trend, with the mean scores increasing steadily from the pre to post test and then to the retention test, suggesting continuous progress in participants' achievement in Arduino.

For Arduino (AAT) and mBlock (MBT), repeated measures analyses revealed statistically significant differences among pre-test, post-test, and retention test scores (Tables 5-8). Mean scores increased steadily across measurement points, with retention test results exceeding post test scores. This pattern suggests that learning gains were not only immediate but also sustained over time, particularly in applied and practice-oriented domains such as Arduino and mBlock.

Table 6.
Results of ANOVA for the AAT

	SS	df	MS	F	p
Sphericity Assumed	447.586	2	223.793	103.105	0.000

The ANOVA results indicated in Table 6 that the pre-test, post-test, and retention test scores differed significantly from one another ($p<.05$). These findings imply that the instructional activities had a meaningful and lasting impact on PST's Arduino knowledge and skills. The consistent increases across all three measures demonstrate immediate learning gains and sustained retention, confirming that the training achieved its intended objectives.

Table 7.
MBT Descriptive Statistics

	N	M	SD	p
Pre-test	37	5.72	1.78	0.342
Post-test	37	7.21	1.37	
Retention	37	9.13	1.00	

Mauchly's test showed no violation of sphericity ($p > .05$) (Table 7). The descriptive statistics show a steady increase in mean scores across all the tests, indicating progressive improvement in participants' performance on mBlock.

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Table 8.
Results of ANOVA for the MBT

	SS	df	MS	F	p
Sphericity Assumed	215.694	2	107.847	65.267	0.000

As presented in Table 8, test scores differed significantly across the three measurement periods, $F(2, 72) = 65.267$, $p < .05$. This finding suggests that the instructional activities had a meaningful and sustained impact on participants' mBlock achievement. Steady gains in score demonstrate effective knowledge acquisition and skill retention resulting from the training.

Findings Related to Research Question 3: Pedagogicall Views

Qualitative findings obtained from semi-structured interviews were organized to reflect how PSTs interpreted and experienced the instructional process in relation to the quantitative outcomes. To reduce thematic overlap and enhance analytical clarity, related themes were grouped under three broader categories: (a) learning engagement and participation, (b) instructional design and material development, and (c) perceived challenges and instructional needs. Representative quotations selected to illustrate each category are presented in Table 9.

Learning Engagement and Participation

PSTs frequently reported that mBlock and Arduino applications increased students' interest, attention, and active participation in science lessons. Statements highlighted that hands-on interactions and collaborative activities made learning experiences more engaging and motivating.

Instructional Design and Material Development

A large majority of PSTs emphasized the pedagogical value of designing instructional materials using mBlock and Arduino. PSTs indicated that material development facilitated concretization of abstract concepts, like electical circuits, and supported more permanent learning. Several responses also reflected participants' intention to integrate such materials into future science lessons.

Perceived Challenges and Instructional Needs

Although many PSTs expressed confidence in using block-based coding environments, some reported anticipated difficulties, particularly regarding Arduino, due to limited prior knowledge or resource constraints. PSTs expressed a strong demand for allocating a separate course hour to coding supported science activities, associating these activities with increased effectiveness and student motivation.

Importantly, these qualitative findings help explain the quantitative results by highlighting the mechanisms underlying the observed improvements. Increased engagement, active participation, and material design experiences appear to have contributed to both enhanced self-efficacy and improved learning outcomes.

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Table 9.
Themes, Categories, Codes, and Sample Excerpts from the Semi Structured Interviews

Theme	Category	Code	Sample Quotation
Increased Interest and Engagement	Students' attention and motivation	Attracting interest and participation	"Because students have something to work on, it makes the lesson more fun and engaging." (PST10). "The applications are attention-grabbing." (PST20) "They would increase students' interest in science lessons." (PST21)
Necessity of Material Development	Teaching with self-designed materials	Enhancing retention through materials	"Developing and teaching with materials would attract students' interest more and lead to more permanent learning." (PST23) "Using mBlock and Arduino makes learning more lasting because students learn by doing." (PST2) "Material development helps students visualize what they learn and understand better." (PST14)
Challenges in Implementation	Knowledge and resource limitations	Lack of technical knowledge	"I think I wouldn't struggle because I received the basics of Arduino, but with more training, I could produce better content." (PST6) "Limited resources might make it difficult to ensure every student's participation." (PST17)
Perceived Necessity in Science Lessons	Improving learning outcomes	Concretization of abstract concepts	"Yes, it is necessary because it provides concrete learning and makes students love the subject more." (PST1) "It helps students visualize concepts and understand them more easily, turning theory into practice." (PST29)
Applications and Inventions	Purpose of design and innovation	Educational and practical uses	"Using a distance sensor to measure heights or distances in construction." (PST7) "Designing a lightning simulation to make science lessons more engaging." (PST32)
Collaboration and Motivation	Peer interaction and teamwork	Group learning and idea exchange	"Group work helps us complete our deficiencies and discuss ideas together to create a project." (PST5) "Shared decision-making and the reciprocal flow of ideas made the process much more productive." (PST12) "Working in groups made me more curious and motivated; we learned a lot from each other." (PST12)
Preferred Topics for Teaching	Subject preferences	Earth and the Universe as priority	"I would prefer to teach topics related to Earth and the Universe first." (PST9)
Social Reactions and Dissemination	Sharing experiences with peers	Positive community feedback	"I talked to my friends; they were curious, and I explained it to them in detail." (PST6) "They were very surprised, found it cool, and some even decided to take a course." (PST17)
Demand for a Separate Course Hour	Curriculum integration	Increasing interest and motivation	"It would attract attention by doing something different and make abstract concepts more concrete and memorable." (PST18) "Allocating a separate course hour for mBlock and Arduino would make lessons more effective and motivate students to participate actively." (PST24) "Such a course would help students grasp abstract science concepts more easily and develop their creativity." (PST36).

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Discussion

The present study employed an explanatory sequential mixed methods design to investigate changes in PSTs' programming self-efficacy perceptions and learning outcomes, and to explain them through their experiences. Accordingly, this section integrates quantitative and qualitative findings and situates them within the relevant literature to clarify how and why block-based coding and Arduino-supported activities influenced both cognitive and affective outcomes.

Integration of Quantitative and Qualitative Findings

The quantitative results demonstrated statistically significant improvements in both perceptions of programming self-efficacy and in achievement across all measured domains, including algorithmic thinking, basic electronics, Arduino, and mBlock. The qualitative findings provide explanatory insight into these results by highlighting the learning experiences that PSTs associated with their development. PSTs frequently emphasized active participation, hands-on experimentation, collaborative work, and material design as central elements of the instructional process. Similar patterns have been reported in previous studies, indicating that block-based coding environments foster engagement and confidence by allowing learners to interact directly with technological systems (Arslan & Tanel, 2021; Bower at al. 2017; Sanusi et al., 2025; Çoban et al., 2020).

From a theoretical perspective, the observed increase in programming self-efficacy can be interpreted through Bandura's self-efficacy framework. PSTs repeated successes in completing coding tasks, constructing circuits, and observing immediate outcomes represent mastery experiences, which are considered the most influential source of self-efficacy development. In addition, peer collaboration and group-based problem solving, frequently mentioned in the qualitative findings, align with vicarious experiences and social persuasion, further reinforcing confidence beliefs. Similar mechanisms have been reported in studies examining the relationship between coding activities, computational thinking, and self-efficacy among preservice teachers (Ateşkan & Hart, 2021; Ortega-Ruipérez & Lázaro Alcalde, 2023).

Learning Outcomes, Retention, and Instructional Design

The significant gains observed in achievement tests, particularly the sustained improvement in Arduino and mBlock retention scores, suggest that learning extended beyond short term performance. This finding is consistent with previous research showing that block-based coding and robotics applications, when combined with hands-on practices, enhance academic achievement and support durable learning (Coşkunserçe, 2023; Ga & Chang, 2025). Qualitative findings help explain this durability by revealing that participants perceived material design and experimentation as key contributors to meaningful learning.

Designing instructional materials using mBlock and Arduino required PSTs to integrate theoretical knowledge with practical implementation, which aligns with constructivist and experiential learning principles. Similar conclusions have been drawn in studies emphasizing that coding supported material development facilitates the concretization of abstract scientific concepts and promotes learning by doing (Ga & Chang, 2025). In this sense, the present study extends earlier findings by demonstrating that material design functions as a mediating process between coding activities and sustained learning outcomes in science teacher education.

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Programming Self-Efficacy and Pedagogical Readiness

The increased programming self-efficacy observed in this study is consistent with previous research indicating that block-based coding reduces anxiety and cognitive load while supporting the development of confidence among novice learners (Köksaloğlu, 2022; Unal & Topu, 2021; Şentürk & Sari, 2025). PSTs' qualitative responses further suggest that feeling competent in using coding tools enhanced their readiness to integrate these technologies into future science teaching. This finding aligns with studies reporting that preservice teachers with higher self-efficacy are more likely to adopt technology integrated instructional practices (Bower et al., 2017; Hur, 2021).

Moreover, PSTs' emphasis on active engagement, curiosity, and motivation supports the argument that affective gains play a crucial role in technology adoption. Previous studies have similarly highlighted that positive attitudes and interest are essential precursors to sustained engagement with coding and robotics in educational contexts (Şentürk & Sari, 2025).

Challenges, Cognitive Load, and Structural Constraints

Despite the overall positive outcomes, some PSTs anticipated difficulties in implementing Arduino based activities, particularly due to limited prior knowledge and resource constraints. These concerns are consistent with earlier studies reporting technical challenges, infrastructure limitations, and insufficient instructional time as barriers to effective coding integration (Bower et al. 2017; Rao & Bhagat, 2024; Ortega-Ruipérez & Lázaro Alcalde, 2023). Such challenges may increase cognitive load and reduce teachers' willingness to experiment with technology in real classroom settings.

In this context, PSTs' strong demand for a separate course hour dedicated to mBlock and Arduino activities should be interpreted as a structural need rather than a personal preference. Similar recommendations have been made in prior research emphasizing that sufficient instructional time and institutional support are critical for developing coding competencies and pedagogical confidence (Bower et al., 2017; Govender et al., 2025). Addressing these constraints may enhance the scalability and sustainability of coding supported science instruction.

Positioning the Study within the Literature

While many previous studies have reported positive effects of block-based coding and Arduino on attitudes, achievement, or computational thinking, they often focus on a single outcome or rely on descriptive analyses. The present study contributes to the literature by integrating programming self-efficacy, achievement, and retention within a single explanatory sequential mixed methods framework. In addition, by situating coding activities within a specific science content domain, electrical circuits, the study responds to calls for more context specific and pedagogically grounded research in science teacher education (Govender et al., 2025; Vasconcelos & Kim, 2022).

Conclusions

This study demonstrates that integrating block-based coding and Arduino into PST education can lead to significant improvements in programming self-efficacy and learning outcomes. The explanatory sequential mixed methods design revealed not

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only measurable gains in achievement and retention, but also the experiential factors such as active participation, material design, and collaboration that underpin these gains. These findings contribute to the literature by showing that technology-integrated instructional processes are effective not only in improving cognitive outcomes but also in strengthening affective dimensions such as self-efficacy, which plays a critical role in teachers' willingness to integrate technology into their future practices.

By positioning PSTs as instructional designers rather than passive technology users, the study highlights the pedagogical value of coding-supported material development in science education. From a pedagogical perspective, the study highlights the importance of positioning digital technologies as tools for instructional design rather than as ends in themselves. At the same time, identified challenges related to technical complexity and instructional time underscore the need for structured support within teacher education programs.

Overall, the findings suggest that block-based coding and Arduino, when systematically integrated into science teacher training, can strengthen both cognitive and affective dimensions of learning and contribute to the development of digitally competent and pedagogically confident science teachers.

Limitations and Recommendations for Future Studies

This study was limited to a small sample of participants from a single institution. Future studies necessitate larger and more diverse samples to improve generalizability.

Only block-based programming was used. Comparative studies of block-based and text-based programming (mBlock vs. Arduino interface) are recommended.

The research focused on a single content area. Expanding to multiple domains of science (Earth and the Universe, Physical Phenomena, Matter and Change, Living Things and Life) could provide broader insights.

Because Arduino materials are costly, replication studies using simulation platforms such as Proteus are recommended.

Further research may examine whether factors such as gender, age, or type of high school influence performance and perceptions in coding activities.

The findings have implications for teacher training. Future studies could develop in-service professional development programs to support the integration of mBlock and Arduino into science education.

Statements and Declarations

This study was approved by the Ethics Committee of University Ondokuz Mayis, Approval No: 2019-329, Date: 25.10.2019, and all procedures were carried out in accordance with institutional and international ethical standards. The authors declare that no financial support was received for the conduct or publication of this research. The study was conducted independently, without any external funding or sponsorship.

This study was conducted as part of the first author's master's thesis research, supervised by the second author.

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Original Article

Digital technologies and artificial intelligence for multicultural competence in high school literature

Tecnologías digitales e inteligencia artificial para la competencia multicultural en literatura de secundaria

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Abstract

The development of skills to effectively interact, adapt, and maintain relationships in a diverse socio-cultural environment is becoming particularly relevant in the education system. The aim of the research was to study the possibilities of building students' multicultural competence in literature lessons using digital technologies. The study used empirical methods such as experiment, observation, evaluation and questionnaire. During the experiment, services for creating text, visual and video content based on artificial intelligence were used, in particular: OpenAI, MidJourney, Synthesia, DeepAI, Runway ML. Student collaboration, discussions and debates were implemented using Google Teams, Telegram and Zoom services. Assessment was carried out using a mobile application developed on the SkillzRun platform. The concept of the online Foreign Literature course was elaborated to develop multicultural competence in secondary school students in a digital environment. An educational experiment was conducted with the participation of 130 students of 10 grades aged 15-16 years of secondary schools of Ukraine. The level of development of multicultural competence in students of the control group (CG) and experimental group (EG) was assessed after the educational experiment. The testing results showed that digital technologies enable students to expand their perception of literary works and motivate them to carry out more detailed analysis. This, in turn, contributes to active interaction with texts, the development of cultural intelligence, and the intercultural communication skills. The level of knowledge in the subject showed that students who participated in the educational experiment had higher scores. They scored 9.1 points on average, while the CG students scored 7.8 points only. The study confirmed that studying foreign literature through IT technologies enhances students' interest in the cultural diversity of the peoples of the world, develops cultural sensitivity, and stimulates the practice of key multicultural skills. Prospects for further research will be creating a universal pedagogical model for the development of multicultural competencies for secondary school students with an orientation to the cognitive, value-motivational, emotional and behavioral components. Special attention will be paid to the development of effective pedagogical approaches to the integration of cultural diversity into the educational space.

Keywords: artificial intelligence, digital environment, interactive learning, intercultural interaction, multicultural education.

Resumen

El desarrollo de competencias para interactuar, adaptarse y mantener relaciones eficaces en un entorno sociocultural diverso está adquiriendo una importancia particular en el sistema educativo. El objetivo de la investigación era estudiar las posibilidades de construir la competencia multicultural de los estudiantes en las clases de literatura utilizando tecnologías digitales. El estudio empírico empírico utilizó métodos como la experimentación, la observación, la evaluación y el cuestionario. Durante el experimento, se emplearon servicios de creación de contenido textual, visual y de vídeo basados en inteligencia artificial, en particular:

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OpenAI, MidJourney, Synthesia, DeepAI y Runway ML. La colaboración, las discusiones y los debates estudiantiles se implementaron mediante Google Teams, Telegram y Zoom. La evaluación se realizó mediante una aplicación móvil desarrollada en la plataforma SkillzRun. El concepto del curso en línea de literatura extranjera se elaboró para desarrollar la competencia multicultural en los estudiantes de secundaria en un entorno digital. Se llevó a cabo un experimento educativo con la participación de 130 estudiantes de 10 grados de 15-16 años de las escuelas secundarias de Ucrania. Se evaluó el nivel de desarrollo de la competencia multicultural en los alumnos del grupo control (GC) y del grupo experimental (GE) después del experimento educativo. Los resultados de las pruebas mostraron que las tecnologías digitales permiten a los estudiantes ampliar su percepción de las obras literarias y motivarlos para llevar a cabo un análisis más detallado. Esto, a su vez, contribuye a la interacción activa con los textos, el desarrollo de la inteligencia cultural y las habilidades de comunicación intercultural. El nivel de conocimiento en la asignatura mostró que los estudiantes que participaron en el experimento educativo tenían puntajes más altos. En promedio, obtuvieron 9,1 puntos, mientras que los estudiantes de GC obtuvieron solo 7,8 puntos. El estudio confirmó que el estudio de la literatura extranjera a través de las tecnologías de la información aumenta el interés de los estudiantes por la diversidad cultural de los pueblos del mundo, desarrolla la sensibilidad cultural y estimula la práctica de competencias multiculturales clave. Las perspectivas de investigación futuras serán la creación de un modelo pedagógico universal para el desarrollo de competencias multiculturales en estudiantes de secundaria, con énfasis en los componentes cognitivos, motivacionales, emocionales y conductuales. Se prestará especial atención al desarrollo de enfoques pedagógicos eficaces para la integración de la diversidad cultural en el ámbito educativo.

Palabras clave: aprendizaje interactivo, educación multicultural, entorno digital, inteligencia artificial, interacción intercultural.

Introduction

In an era of increasing cultural interconnectedness, multicultural competence is a valuable resource for shaping intercultural interaction, professional and personal self-realization. The challenges and prospects of global multiculturalism increase the need to integrate targeted socio-cultural educational practices into the school learning environment. The integration of literary learning and intercultural education opens the way to the formation of socio-cultural awareness of students, promoting adaptability in international contexts and competence in intercultural communications.

The development of students' integrated sociocultural awareness is based on two key competencies: cultural empathy and cognitive awareness of cultural diversity. In the study of Roza & Guimarães (2022), a clear relationship between literary reading and the development of empathy in children and adolescents is outlined. The authors argue that literary interventions can qualitatively influence the development of empathic competencies, cognitive functions and emotional intelligence. According to Qi & You (2025), the emotional integration of foreign narratives in the process of reading foreign literature promotes a personal connection with the multicultural context and strengthens cultural empathy. The authors emphasize that foreign literature is an influential tool for the development of intercultural empathy, opening up the experience of diverse cultural perspectives. Davis (2020) notes that the cultural component plays an important role in the formation of intercultural competence. Milovanović (2025) argues that cultural empathy should be considered as a culturally mediated phenomenon, formed through symbolic interaction, integration into social communicative practices. In his opinion, empathy forms the basis of emotional literacy, social responsibility and intercultural understanding. This

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statement is supported by Finkelstein & Soffer-Vital (2025) noting that cultural empathy, which involves a tolerant attitude, understanding and respect for diverse points of view, is critically important for cooperation and effective communication in a multicultural environment.

Cultural empathy and cognitive awareness of cultural diversity are manifestations of intercultural competence. Bakum et al. (2022), considers multicultural competence through the prism of four interconnected and interdependent components: linguistic, sociocultural, functional and emotional-axiological. According to Urgun, et al. (2025) intercultural competence should be considered as a set of personal characteristics - intercultural traits, intercultural abilities and intercultural attitudes and worldviews. According to Kremer & Pinto (2025), along with the main components of intercultural competence, such as cultural sensitivity, empathy, awareness and adaptability, social integration and communication skills play an important role. According to the authors, the ability to participate in sociocultural interaction, critically evaluate cultural contexts and adapt to sociocultural realities form the functional basis of multicultural competence. According to Pintor & Premazzi (2024), Sarwari et al. (2024) adaptability in communication and tolerant attitude towards different cultures are manifestations of the formation of intercultural competence. According to Hamaniuk et al. (2024), intercultural competence involves the ability to adapt, form mutual understanding and effective interaction with representatives of other cultures in a diverse socio-cultural environment. Chyzhykova et al. (2022) identifies the professional context of intercultural competence, which reflects the ability of an individual to form effective business relationships in a multinational environment. According to the authors of the study, multicultural competence includes knowledge and understanding of different cultural characteristics, the ability to interact with representatives of different cultures. The ability to be sensitive, tolerant and flexible in interaction with different cultural contexts, as well as to adapt one's personal perception to the national values of other cultures is extremely important. The development of multicultural competencies of students in high school, stimulating the development of cultural empathy, intercultural tolerance and respect in the process of literary learning achieves progress provided that it is structured and modern teaching methods are implemented. Our statement is supported by to Qi & You (2025), who believe that the use of blended learning methods in literature lessons with the use of modern digital technologies improves empathic understanding and critical thinking in students.

In the context of globalization and digital transformation, intercultural interaction urges the issues of developing multicultural competence in educational contexts. The issues of creating conditions favourable for the development of multicultural competence in the educational environment are being studied by educators and researchers. Academic research mainly focuses on the instrumental, methodological and technological characteristics of digital pedagogical solutions, ignoring their impact on the development of multicultural competence in the process of educational activity. The hypothesis of this study is that the use of digital technologies in foreign literature lessons has a positive effect on the development of key elements of multicultural competence. In particular, this applies to the textual, interpretative, communicative, aesthetic, value and content, cultural, creative, and adaptive components. The academic novelty of the study is the identified and substantiated pedagogical ways of developing multicultural competence in secondary school students studying literary subjects. A pedagogical strategy for the development of multicultural competence using digital technologies is proposed, taking into account the synergy of individual and collective teaching methods.

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The aim of this research was to study the possibilities of building students' multicultural competence in literature lessons using digital technologies. The aim was achieved through the fulfilment of the following research objectives:

- Create a concept for an online educational Foreign Literature course aimed at the development of multicultural competence and model a digital learning environment for high-quality students' interaction in the process of studying the subject;
- Conduct an educational experiment with the participation of 10th grade students of secondary schools of Ukraine;
- Assess the level of development of multicultural competence in the CG and EG students after the educational experiment;
- Conduct students' survey and determine their attitude to the possibilities of developing the necessary competencies for high-quality socio-cultural interaction in the global digital space;
- Assess students' attitude to collective and individualized educational strategies of digital learning and digital teaching methods.

Literature Review

Modern school education is experiencing a dynamic era of transformations caused by the convergence of advanced technologies and innovative teaching methods. Modern digital technologies open up opportunities for improving educational scenarios through management, analytics and personalization functions (Ellikkal & Rajamohan, 2024), gamification and simulation (Gautam & Dua, 2021). According to Schön et al. (2023), the introduction of modern digital services based on artificial intelligence (AI) into educational interactions allows to improve the quality and efficiency of learning. Nguyen, et al., (2022) note the impact of AI on changing approaches to learning towards personalization and adaptability. And Archibald et al. (2023) note the prospects of AI in improving the assessment and moderation of the educational process. Dynamic planning of personalized learning paths using adaptive AI-based systems (Li, et al., 2024) transforms approaches to learning and the educational environment, making it adapted to the needs of students. According to Chovriy et al. (2024), the generative functions of modern digital technologies can increase student engagement by modeling an interactive learning environment with gamification elements. Möller et al. (2024) emphasize that the integration of digital technologies into educational contexts can significantly increase student success. Kocot et al. (2024) note that the potential of digital integration can be revealed under the condition of technological support, the quality of educational content, and the ability of students to learn independently. According to the authors of this study, the integration of modern digital tools into students' educational scenarios allows diversifying and improving the learning experience, creating an environment of high-quality interaction, and realizing the potential of innovative teaching methods. The integration of AI into educational practices allows for increased motivation and increased knowledge acquisition by diversifying the learning load, diversifying it, and modernizing educational content.

Digital technologies expand the possibilities of studying literature by allowing students to delve deeper into the cultural component of the world's literary heritage. Interaction with literary cultural content in a digital environment reveals the research potential of students, which includes the ability to analyze, evaluate, argue and identify key features inherent in a particular culture. According to Alfaruque, et al. (2023), digital technologies have transformed traditional approaches to studying literature. Multimedia visualizations, electronic editions of

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classic works, video storytelling, graphic adaptations, interactive hypertexts and remote reading platforms expand interpretive possibilities. Modern digital tools allow you to model the structure of the text, create digital artifacts and maps of artistic space, visualize thematic lines and deepen the analytical perception of a literary work. According to Guo (2025), digital tools will enrich students' learning experience, positively affect students' motivation and understanding of complex literary concepts. Daghamin & Daghamin (2025) argue that the integration of digital technologies based on artificial intelligence into literary teaching allows students to personalize their approach to systematic work with literary topics, create their own unique methods of reading and analyzing literature, and improve the comparative analysis of different literary works. According to the authors of this study, the study of literature in a digital educational environment contributes to the development of cultural empathy, integrating the student's attention into cultural literary content and stimulating cognitive research interest. The generative functions of digital technologies have powerful potential for modelling an engaging learning environment with elements of gamification and interactivity.

Given the trends of digital transformation in education, strategies for implementing digital tools in educational interactions require in-depth research. Despite the significant contribution of researchers to the study of the possibilities of digital technologies in educational contexts, some aspects remain poorly covered. In particular, we are talking about the possibilities, advantages and disadvantages of using digital tools in the study of the humanities. Furthermore, the issue of developing global multicultural competencies in a digital environment within the framework of secondary education curricula requires additional research.

Methodology

Research stages

The research was conducted from January to May 2025. The stages of the research are presented in Figure 1.

Sampling

The educational experiment involved 130 10th grade students aged 15-16 from secondary schools in Ukraine. An official invitation was sent to the directorates of 27 schools with a proposal to participate in the study. The aim of the appeal was to involve 10th grade students in an educational experiment, survey and exchange of experience on the appropriateness of using digital technologies in literature lessons. It was also intended to study the impact of these technologies on the development of key elements of multicultural competence. Involvement in the experiment was voluntary. An online registration form was developed for students to participate in the study, which was a tool for collecting basic data about the participants. The form provided for information about the educational institution, grade, age, as well as consent to participate in the study. As of the beginning of January 2025, 167 applications from students to participate in the study were received. The initial analysis of the questionnaire data and the participants' compliance with the research criteria was followed by a screening, during which some of the applications were rejected. The main sample included 130 participants who met the established requirements and expressed their willingness to actively participate in all stages of the experiment. The main inclusion criteria were age 15-16 years and studying in the 10th grade of secondary schools in Ukraine.

Two groups of participants were randomly formed to ensure the objectivity of the

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research results: the EG and the CG. For 4 months, the EG students (65 students) participated in the educational experiment. The experiment was based on the author's model of developing multicultural competence in secondary school students using modern digital tools in the Foreign Literature. The CG participants studied using the traditional method according to the curriculum. The educational online Foreign Literature course was developed and the educational experiment was conducted by 6 teachers of the Ferenc Rakoczi II Transcarpathian Hungarian College of Higher Education and Borys Grinchenko Kyiv Metropolitan University.

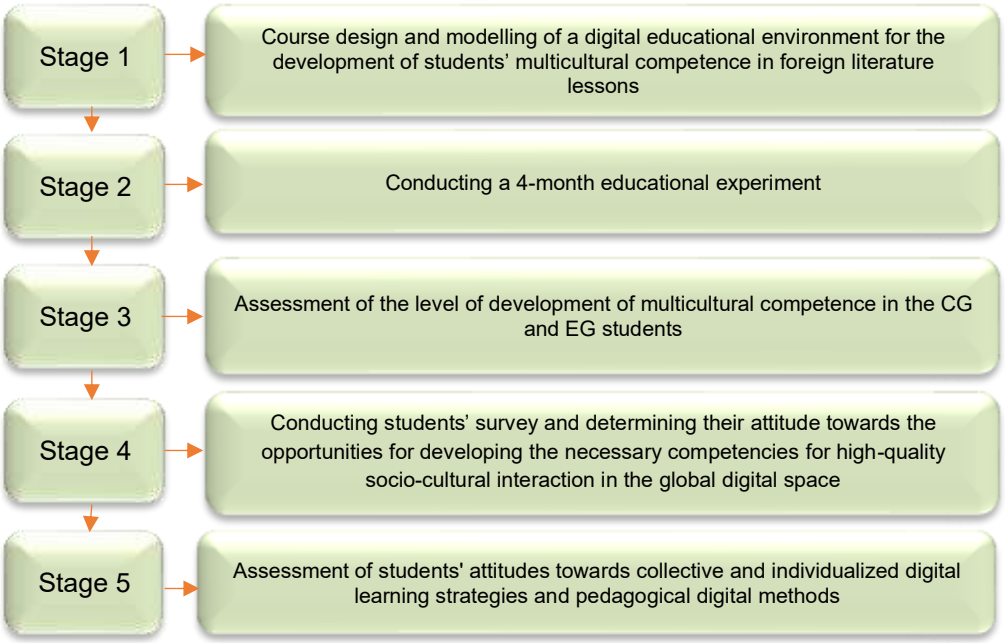


Figure 1. Research stages
Source: developed by the authors

Methods

- The experimental method was applied in the process of modelling the educational digital environment and the structure of the online Foreign Literature course, as well as during the experimental training of students in the course. The experiment involved individual and group learning. Students were involved in various activities in a digital environment, including communicative games, group discussions, seminars, virtual tours and excursions, and digital creativity using services for creating text, visual, and video content based on artificial intelligence;
- The observation method was used to record the activity and involvement of students in the learning process;
- The assessment method was used to assess the level of development of multicultural competence in the CG and EG students after the educational experiment. The testing included 10 situational tasks for assessing each element of multicultural competence, in particular: textual interpretative, communicative, aesthetic, value and content, cultural, creative, adaptive competencies. The assessment was carried out on a 12-point system
- The survey method was used to: 1) assess students' attitudes towards opportunities to develop the necessary competencies for high-quality socio-cultural interaction in the global digital space; 2) assess students' attitudes

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towards collective and individualized learning strategies for digital learning and pedagogical digital methods. It was carried out by means of a questionnaire. The questionnaire contained 3 blocks of 10 statements, with which respondents could assess their position on a Likert scale from 1 to 5 points. The first block of statements was aimed at assessing students' attitudes towards opportunities to develop the necessary competencies for high-quality socio-cultural interaction in the global digital space. The second block was aimed at assessing students' attitudes towards collective and individualized learning strategies for digital learning. The third block was aimed at assessing students' attitudes towards digital teaching methods. The questionnaire was developed by the authors of the study independently based on an analysis of academic literature, taking into account the aim and objectives of the study. It was tested through a pilot survey ($n = 40$) with a second survey after two weeks. The results of the t-test: $t(29) = -0.62$, $p = 0.542$, indicating the stability of the responses. Cronbach's $\alpha = 0.81$ confirmed high internal consistency. The questionnaire demonstrated sufficient reliability and was used as the main tool for collecting empirical data in further research.

– The analytical method was used to structure the survey results, draw conclusions and recommendations to improve the effectiveness of developing students' multicultural competence in the Foreign Literature lessons using digital technologies.

Instruments

1. Individual learning strategies for the Foreign Literature subject for the EG students were implemented and the knowledge and level of multicultural competence of all participants was tested using a mobile application. This application was developed on the SkillzRun platform.
2. Students' joint work on the study of cultural features of literary works was carried out using the Google Teams service and the Google Teams communication service;
3. In working on creative projects, students used services for creating text, visual and video content based on AI, in particular: OpenAI, MidJourney, Synthesia, DeepAI, Runway ML.
4. Group discussions and exchange of experience were carried out in the educational experiment community on Telegram;
5. Coordination meetings with course moderators were carried out in Zoom.
6. The obtained data were analysed and processed using Microsoft Excel.

Results and Discussion

The educational experiment proved that studying literature in the modern digital space enables students to acquire the knowledge, skills and practical qualities necessary for high-quality interaction with the international environment. Communication games, seminars, virtual reviews and excursions, as well as visual generation of literary images had a positive impact on the level of students' multicultural competence. Interaction with educational video content created using AI contributed to the development of analytical and creative skills. In addition, joint work on projects and conducting group research also made a significant contribution to improving intercultural interaction among students. The assessment results showed that the EG students demonstrated a higher level of development of elements of multicultural competence than the CG students (Figure 2).

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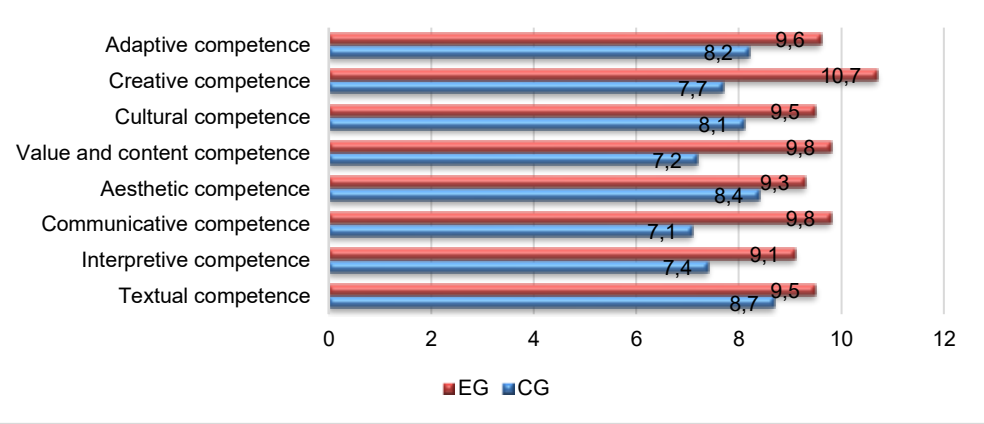


Figure 2. Assessment of the level of development of multicultural competence
Source: created by the authors

The analysis of the test results proved that digital technologies enable students to expand their perception of literary works. They motivate students to more detailed analysis and active interaction with texts, which contributes to the development of their cultural intelligence and intercultural communication skills. In addition, the results of testing the level of knowledge in the Foreign Literature showed that students who participated in the educational experiment had higher scores. Their scores were 9.1 on average, while this indicator was 7.8 for the CG students. The implemented pedagogical methods, which involved group learning in a simulated digital environment, have proven their effectiveness in the context of developing multicultural competence. The results of the student survey showed that digital technologies are able to improve the quality and efficiency of the educational process. They contribute to the development not only of key elements of multicultural competence, but also of skills for high-quality socio-cultural interaction in the global digital space. The results of the student survey are presented in Table 1.

Table 1.
Students' attitudes towards opportunities to develop the necessary competencies for high-quality socio-cultural interaction in the global digital space

Statement	Rating scale				
Interaction with digital technologies in literature lessons contributed to:	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
development of digital literacy			2%	3%	95%
development of information literacy and analytical skills		1%	2%	4%	93%
development of responsibility, diligence and the ability to prioritize		2%	5%	6%	87%
development of practical literary knowledge and skills			2%	7%	91%
development of critical thinking, problem-solving and decision-making skills		1%	2%	4%	83%
development of flexibility of thinking, the ability to quickly perceive information	5%	7%	6%	4%	78%
development of communication skills, cooperation and collaboration skills in the digital environment	4%	8%	6%	7%	75%

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development of the ability to analyse information, check facts, identify false arguments	4%	5%	4%	6%	81%
development of critical and creative thinking	3%	5%	7%	9%	76%
development of adaptability to different cultural contexts			4%	10%	86%

Source: created by the authors

The results of the student survey allowed for a comprehensive assessment of their attitudes towards the opportunities for developing multicultural competencies in the digital information space. In general, students confirmed the value of learning experience in a digital environment and its positive impact on the development of multicultural competence, noting its flexibility, accessibility and comfort. The next stage of the research was to study students' preferences in choosing learning strategies, in particular individual and collective. Table 2 presents the results of the survey.

Table 2.
Students' attitudes towards collective and individualized digital learning strategies

Statement	Rating scale				
	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Individualized tasks and approaches to learning contribute to better assimilation of literary material		9%	15%	12%	64%
A learning process adapted to the student's level of knowledge, needs and expectations contributes to the effectiveness of learning		6%	11%	8%	75%
Individualized learning strategies enable better planning one's own time and pace of learning	4%	10%	7%	8%	71%
Individual distance consultations with a teacher help to understand and assimilate the material more deeply			3%	12%	85%
Collective learning interactions have a noticeable impact on learning and the development of multicultural competencies			1%	3%	96%
Group learning contributes to faster and more qualitative assimilation of material				6%	94%
Joint work on projects increases the effectiveness of learning				9%	91%
A collective approach to learning creates an effective learning environment, enabling an exchange of ideas, learning from others, and creating an atmosphere of mutual support			1%	2%	97%
Group learning contributes to the comfortable and convenient development of multicultural competence				2%	98%

Source: created by the authors

The survey results clearly identified the students' educational preferences, which were largely oriented towards collective learning strategies. However, observation

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of the participants in the educational experiment showed that the use of the capabilities of modern adaptive digital technologies in the educational process can qualitatively increase the effectiveness of collective learning interactions. This also contributes to the consolidation of knowledge and skills. Therefore, the combination of collective and individualized learning strategies aimed at the development of multicultural competencies is the optimal solution in the creation and design of educational scenarios. Furthermore, the students' attitude to online learning methods and their potential in increasing educational self-efficacy, engagement and motivation was studied. The survey results are presented in Table 3.

Table 3.
Students' attitudes towards pedagogical digital methods and approaches

Statement	Rating scale				
	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Personalized tasks and recommendations based on the analysis of student success make learning more focused and motivating		3%	7%	6%	84%
The use of interactive digital materials helps to increase interest in learning and better assimilation of the material			2%	7%	91%
Mobile and online platforms that offer access to educational materials at any time enable effective organization of learning			7%	6%	87%
The use of game elements (gamification) in learning stimulates more active participation in the learning process				4%	96%
Group classes and discussion of educational materials with other students in an online format engages in learning and helps improve learning outcomes			1%	2%	97%
Interactive situational tasks make the learning process more exciting			2%	3%	95%

Source: created by the authors

The survey results showed that modern educational technologies open up new opportunities for the development of relevant multicultural skills in secondary school students. At the same time, they provide a high level of educational motivation and engagement. The results of this study confirmed that the study of foreign literature in the environment of the latest IT technologies enhances students' interest in the cultural diversity of the peoples of the world. It also develops cultural sensitivity and stimulates the practice of key multicultural skills.

One of the priorities of literature education is to develop students' ability to independently analyze and interpret literary texts. It is also important that students are aware of and understand the aesthetic, spiritual, and moral values embedded in these texts. The results of a study by Guo (2025) confirmed that the integration of digital tools into literature courses significantly increases student engagement, participation, and understanding, and improves academic performance and critical thinking. The results of the study by Daghamin & Daghamin (2025) confirmed that the use of artificial intelligence in the process of analyzing a literary work helps students interpret and critically analyze literature, supporting authentic literary interpretation.

This study demonstrated that group discussions of literary works, as well as the joint creation of video content aimed at identifying cultural differences, allowed students

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to develop cultural knowledge. The results of a study by Urgun et al. (2025), proved the effectiveness of blended learning methods and their impact on the development of students' intercultural competence in the process of implementing intercultural curricula. This is consistent with our opinion, since we believe that participation in collaborative learning in an online environment and interaction with artificial intelligence services for creating digital content are important factors. Developing interest in cultural diversity through active learning and project work with literary texts affects the increase in the level of multicultural competence of students. This opinion is confirmed by the results of Yamada (2025), who proves that digital sources, online communication and interaction play a mediating role between the influence that stimulates learning and the skills that students acquire and apply in further learning.

The results of the study by Sarwari et al. (2024) confirmed that an international educational environment, access to online resources and activities are important components of the learning process. This study presented an educational experiment involving Ukrainian students only. The results of the study showed that the development of students' multicultural competencies remains possible even in the absence of opportunities to implement educational practices in an international educational environment. This is achieved by modelling the educational environment using digital technologies, in particular AI services. As Konstantinidou & Nisiforou (2022) noted, the educational content should be authentic and the learning process should be interactive, multimodal, and attractive.

Another problem in curricula focused on building multicultural competencies is the implementation of an objective assessment of the level of their development in students at different stages of learning. In this study, the level of development of multicultural competence were tested through 10 situational tasks to assess each element of multicultural competence. The assessment was carried out in a mobile application, in an easy and comfortable form for students. The hypothesis of the study was confirmed: the use of digital technologies in foreign literature lessons does have a positive impact on the development of key elements of students' multicultural competence. The results of this study can be used by teachers when designing a learning environment that will promote the development of multicultural competence. The combination of collective and individual learning strategies outlined in the study will enable easy and comfortable realization of students' learning goals.

Limitations

The main limitations of this study are the narrow geographical scope of the educational experiment, as it was conducted among secondary school students in Ukraine. Besides, this is the limited age range of participants (10th grade students aged 15-16) and the short duration of the experiment (4 months).

Recommendations

The results of this study give grounds to outline recommendations for increasing the effectiveness of building students' multicultural competence of in the Foreign Literature lessons using digital technologies, in particular:

- It is necessary to ensure the synergy of individual and group methods of online learning;
- Interactive interactions must be directed towards the development of key elements of multicultural competence;

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- It is necessary to integrate modern digital services and tools into educational interactions and direct students by providing instructions for their active use when working on literary works;
- Increasing the effectiveness of the training course requires the application of pedagogical methods of active project-based problem-oriented learning;
- It is important to coordinate the development directions of both subject and multicultural competencies when modelling educational scenarios for group online learning, so that the trajectories of their development complement and reinforce each other, and do not exclude or displace each other;
- It is necessary to provide additional information and consultation, technological support and ways of direct online communication with students' parents/guardians.

Conclusions

The results of the study confirmed that the literary context plays an important role in the development of multicultural competencies, revealing the values and worldviews of different cultures through language and artistic works. The results of the educational experiment confirmed that the modern use of digital technologies and artificial intelligence in literature lessons with the implementation of individual and group learning strategies has a significant impact on the development of multicultural competence of students. Digital tools based on artificial intelligence provide flexibility and speed of learning, and also contribute to a deeper assimilation of materials, the development of key elements of multicultural competence. Digital technologies contribute to active interaction with literature and culture, developing cultural intelligence and intercultural communication skills.

The results of this study can be used by educators at the stage of designing educational scenarios aimed at the development of multicultural competences in a digital environment. The combination of collective and individual educational strategies outlined in the study will allow to implement educational goals in an easy and comfortable way for students. Prospects for further research include the creation of a universal pedagogical model for the development of multicultural competencies for secondary school students with an orientation to the cognitive, value-motivational, emotional and behavioral components. The implementation of this model will allow for the holistic integration of multicultural competency development strategies into school curricula. Special attention will be paid to the development of effective pedagogical approaches to the integration of cultural diversity into the educational space.

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Original Article

Integration of digital technologies in the development of health literacy among higher education students

Integración de las tecnologías digitales en el desarrollo de la atención sanitaria entre los estudiantes de educación superior

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Abstract

Health literacy has become an essential component of personal well-being and professional competence, particularly in the context of the digital transformation of higher education. This study aims to investigate the effectiveness of integrating digital technologies into the development of health literacy among higher education students during their professional training. The research employed a quasi-experimental design combining theoretical, empirical, and statistical methods. The empirical study involved 161 higher education students divided into a control group (80 participants) and an experimental group (81 participants). Data were collected through questionnaires and surveys designed to assess three components of health literacy: value-motivational, cognitive, and activity. During the formative stage of the experiment, the experimental group was exposed to a set of pedagogical conditions supported by digital technologies, including online learning platforms, learning management systems, webinars, digital communication tools, and mobile health applications. Statistical analysis was conducted using the Pearson chi-square test to determine the significance of differences between groups. The results demonstrated statistically significant improvements in the level of health literacy among students in the experimental group compared with the control group. The findings indicate that the systematic integration of digital technologies into the educational process contributes to the development of health literacy competencies and supports the formation of health-preserving behaviors among future specialists in higher education.

Keywords: health literacy, digital technologies, future specialists, security sphere, digital space, holistic development of the personality.

Resumen

La alfabetización en salud se ha convertido en un componente esencial del bienestar personal y de la formación profesional, especialmente en el contexto de la transformación digital de la educación superior. El presente estudio tiene como objetivo analizar la efectividad de la integración de tecnologías digitales en el desarrollo de la alfabetización en salud entre estudiantes de educación superior durante su formación profesional. La investigación se desarrolló mediante un diseño cuasi experimental que combinó métodos teóricos, empíricos y estadísticos. El estudio empírico incluyó a 161 estudiantes de educación superior distribuidos en un grupo control (80 participantes) y un grupo experimental (81 participantes). La recolección de datos se realizó mediante cuestionarios y encuestas orientados a evaluar tres componentes de la alfabetización en salud: valor-motivacional, cognitivo y de actividad. Durante la etapa formativa del experimento, el grupo experimental participó en un conjunto de condiciones pedagógicas apoyadas en tecnologías digitales, incluyendo plataformas de aprendizaje en línea, sistemas de gestión del aprendizaje,

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seminarios web, herramientas de comunicación digital y aplicaciones móviles relacionadas con la salud. El análisis estadístico se realizó mediante la prueba de chi-cuadrado de Pearson para determinar la significancia de las diferencias entre los grupos. Los resultados evidenciaron mejoras estadísticamente significativas en los niveles de alfabetización en salud en el grupo experimental en comparación con el grupo control.

Palabras clave: alfabetización en salud, tecnologías digitales, futuros especialistas, ámbito de la seguridad, espacio digital, desarrollo holístico de la personalidad.

Introduction

In recent decades, health literacy has become an important component of human development and a key factor influencing individual well-being and the quality of professional activity. In the context of rapid technological progress and the digital transformation of society, the formation of health literacy among higher education students is gaining particular relevance. Health literacy is understood as the ability of individuals to obtain, understand, critically evaluate, and apply health-related information in order to make informed decisions that support a healthy lifestyle and maintain physical, psychological, and social well-being (Vuorikari et al., 2022).

The growing digitalization of education significantly expands opportunities for developing health literacy. Digital tools such as online learning platforms, virtual educational environments, mobile applications, and communication technologies enable access to health information, promote interactive learning, and support the development of practical health-related skills (Tai et al., 2022).

Despite the growing body of research, several important gaps remain in the literature. First, many studies focus primarily on general digital health literacy or on specific population groups such as older adults, while relatively little attention is paid to the development of health literacy among higher education students during their professional training. Second, existing research often examines digital technologies as information sources but provides limited empirical evidence regarding their pedagogical effectiveness in structured educational interventions. Third, insufficient attention has been devoted to identifying specific pedagogical conditions that ensure the effective integration of digital technologies into the process of forming health literacy competencies in future specialists (Yin et al., 2019).

These gaps indicate the need for empirical studies that examine how digital technologies can be systematically integrated into higher education to enhance health literacy and health-preserving competencies among students. In particular, it is important to evaluate whether the use of digital educational tools within a structured pedagogical framework contributes to measurable improvements in students' health literacy levels.

Literature Review

The concept of health literacy has become a central topic in interdisciplinary research at the intersection of education, public health, and digital technologies. The rapid digitalization of society has significantly transformed the ways individuals access, process, and use health-related information. As a result, researchers increasingly emphasize the importance of digital health literacy as a key competency for effective functioning in modern information environments.

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One of the main research trends in this field concerns the growing role of digital technologies in improving access to health information and supporting informed health-related decision-making. Studies indicate that digital environments, including online learning platforms, mobile applications, social networks, and virtual educational spaces, can significantly enhance individuals' ability to obtain and interpret health-related information (Arias López et al., 2023). In addition, digital technologies provide opportunities for interactive learning, personalized information access, and continuous communication between participants in the educational process, which contributes to the development of health-related competencies.

Another important research trend focuses on the relationship between digital inclusion and health literacy. Empirical studies demonstrate that access to digital technologies and the level of digital competence significantly influence the ability of individuals to navigate health information in digital environments. For example, Polonski et al. (2022) investigated the relationship between digital inclusion and health literacy and found that limited access to digital technologies and insufficient digital skills were associated with lower levels of health literacy. These findings highlight the importance of digital competence as a factor influencing the effectiveness of health education initiatives.

Researchers have also explored the pedagogical potential of digital technologies in professional education. Wozniak et al. (2018) analyzed the use of digital tools in health professional education and identified several technologies that significantly influence learning outcomes, including learning management systems, massive open online courses, social media platforms, virtual learning environments, and mobile learning tools. According to the authors, these technologies expand opportunities for collaborative learning, support flexible access to educational resources, and facilitate the development of practical competencies relevant to professional activity.

Technologies for educating a culture of health are based on the formation of ideas about health as a value, on the upbringing of personal qualities in higher education students that constantly contribute to strengthening and preserving their health, increasing responsibility for personal health, strengthening motivation to lead a healthy lifestyle, and family health (Curry & Docherty, 2017).

One of the main innovative forms of student leisure and educational activities is becoming a digital space. Being an active consumer of the digital modern space, a person learns to communicate according to the models provided to them by representatives of mass media. Direct communication disappears from family life in the name of digitalization; the feeling of interaction with others and play are replaced by gadgets (Zhang & Zou, 2020). Children's mastery of digital competence and their safe behavior in the digital space depend largely on parents' and teachers' ability to recognize the risks and opportunities of the digitalization of children's lives. There is an urgent need for parents to develop digital competence as part of their culture, which implies appropriate knowledge of digital technologies and the use of educational platforms, rather than only the appropriate technical level in parents' use of the Internet and computer technology (Galbán & Vidal, 2019).

Modern requirements for training specialists are based on the social demand for health-preserving activities of all specialists; information and communication technologies, new primary digital technologies aimed at the interaction of the teacher and students and the participants of the educational process themselves in order to develop their general human and professional qualities; the need for activities to

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form human health, strengthen, preserve and update the education of students and form health parity (Fancourt et al., 2016).

Analyzing the problem of health preservation in society, we will form the basic concept of “health preservation competence”. We consider the specified competence an integral quality of the student, manifested in the future specialist's general ability to engage in health preservation activities, grounded in the integration of personal values, abilities, skills, and knowledge to preserve mental, social, physical, and spiritual health. With this approach to the concept, we see the creation of a health-preserving environment in the interests of one’s own health, each student’s health, and society's health, as necessary. To do this, it is necessary to make a transition to health preservation forms of education from traditional ones. The created health preservation educational environment, using modern digital technologies, ensures the development of skills to strengthen and preserve health and fosters positive motivation among students toward a healthy lifestyle. The creation of a healthy environment is of great importance for the holistic development of the individual, as the organization of the educational process enables students to realize their abilities across various fields of activity in such conditions (Mendonça & Sousa, 2025).

Previous studies have applied various methodological approaches to investigate health literacy and digital technologies. Quantitative methods are widely used to assess health literacy levels and examine correlations between digital competence and health outcomes. For instance, large-scale surveys and standardized measurement tools such as the Health Literacy Questionnaire (HLQ) and the eHealth Literacy Scale (eHEALS) have been applied to measure different dimensions of health literacy in diverse populations (Galbán & Vidal, 2019). Cross-sectional studies and statistical analyses have been particularly common in public health research focusing on digital health literacy.

At the same time, qualitative approaches have also been employed to explore individuals’ experiences with digital health information and the ways in which digital environments influence learning and health-related behavior. In educational research, experimental and quasi-experimental designs are increasingly used to evaluate the effectiveness of digital learning tools in developing specific competencies, including health literacy.

Despite the growing number of studies in this area, several methodological and conceptual limitations remain. First, many studies primarily focus on measuring health literacy levels or examining correlations between digital access and health outcomes, rather than evaluating the pedagogical effectiveness of digital technologies in structured educational settings. Second, a significant proportion of research concentrates on specific population groups, such as older adults or healthcare professionals, while relatively little attention has been paid to higher education students as future specialists whose professional activities may influence the health and well-being of others.

Another limitation concerns the insufficient integration of digital technologies into pedagogically grounded models of health literacy development. While many studies acknowledge the potential of digital tools, they often analyze them as isolated technological resources rather than as elements of a comprehensive educational environment supported by specific pedagogical conditions. Consequently, the mechanisms through which digital technologies contribute to the formation of health literacy competencies in higher education remain insufficiently explored.

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Furthermore, existing research often presents descriptive analyses of digital tools without providing sufficient empirical evidence regarding their effectiveness in improving students' health literacy within formal educational contexts. This indicates the need for experimental studies that systematically examine the impact of digital technologies on the development of health literacy during professional training.

Therefore, the present study seeks to address these research gaps by empirically investigating the effectiveness of pedagogical conditions for developing health literacy among higher education students through the integration of digital technologies in the educational process. The study contributes to the existing literature by combining theoretical analysis with experimental research aimed at evaluating the impact of digital learning environments on the formation of health-preserving competencies in future specialists.

Methodology

Research design

The study employed a quasi-experimental research design aimed at evaluating the effectiveness of pedagogical conditions for the development of health literacy among higher education students through the integration of digital technologies in the educational process. The research combined theoretical analysis with empirical investigation and statistical verification of the obtained results.

The experimental study was conducted during 2022–2025 and included two stages: an ascertaining stage, which aimed to determine the initial level of health literacy among students, and a formative stage, during which the proposed pedagogical conditions and digital technologies were implemented in the educational process.

Participants

The empirical study involved 161 higher education students participating in professional training programs. The sample consisted of two independent groups: a control group (CG) comprising 80 participants and an experimental group (EG) including 81 participants. The groups were formed to ensure comparability in terms of educational conditions and initial levels of health literacy.

The sample size was determined using statistical principles that ensure the representativeness of the sample and the reliability of the results. The number of participants in each group exceeded the minimum required level for conducting statistical hypothesis testing.

Instruments and data collection

Data collection was carried out using several empirical methods. Questionnaires and surveys were used to assess the level of students' health literacy and to identify their attitudes toward health-preserving practices. Document analysis and observation were also applied to evaluate the educational process and students' engagement with digital learning tools.

The assessment of health literacy was based on three main components:

– **Value-motivational**, reflecting students' awareness of the importance of health and their motivation to maintain it.

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- **Cognitive**, related to knowledge about health preservation and healthy lifestyle practices.
- **Activity**, reflecting the ability to apply knowledge and skills in practical situations, including the use of digital technologies.

For each component, three levels of development were identified: low, medium, and high.

Intervention and use of digital technologies

During the formative stage of the experiment, the experimental group was exposed to a set of pedagogical conditions designed to enhance health literacy through digital technologies. These conditions included the integration of digital learning platforms, online educational resources, webinars, virtual learning environments, and digital communication tools into the educational process.

Students in the experimental group participated in interactive online activities, virtual discussions, and educational projects aimed at developing knowledge and practical skills related to healthy lifestyle practices. Digital tools also enabled continuous access to health-related educational materials and supported collaborative learning and communication among participants in the educational process.

Data analysis

The collected data were analyzed using methods of mathematical statistics to verify the reliability and significance of the results. In particular, statistical hypothesis testing was conducted using the Pearson chi-square (χ^2) criterion to determine the significance of differences between the control and experimental groups.

Two statistical hypotheses were formulated:

- **Null hypothesis (H_0):** there are no significant differences between the control and experimental groups in terms of the level of health literacy formation.
- **Alternative hypothesis (H_1):** there are significant differences between the groups in terms of the level of health literacy formation.

The empirical value of the χ^2 statistic was compared with the critical value at a significance level of $\alpha = 0.05$. If the calculated χ^2 value exceeded the critical value, the null hypothesis was rejected and the alternative hypothesis was accepted, indicating statistically significant differences between the groups.

Ethical considerations

Participation in the study was voluntary, and respondents were informed about the purpose of the research. The data were processed anonymously and used exclusively for scientific purposes.

Results and Discussion

The content and importance of human health for society, and the formation of health literacy through digital technologies, are crucial for future specialists in the holistic development of the personality.

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We consider the formation of health literacy of future specialists using digital technologies as a system of influences that are carried out in the process of professional training of students, providing for the updating of the content of academic disciplines, the use of modern innovative digital technologies to strengthen the health-preserving component of the content of education, aimed at forming in students the motivation for a healthy lifestyle, needs and value orientations regarding health preservation, health-preserving activities; acquiring sustainable knowledge on individual topics related to health and the use of digital technologies to obtain knowledge on the problems of a healthy lifestyle and health preservation; reflecting on one's own health-preserving activities, with the aim of further effective professional activity.

Health-preserving technologies can be classified into the following groups: organizational-pedagogical, psychological-pedagogical, educational, preserving, health-improving, health-teaching technologies, and the upbringing of a culture of health.

Organizational and pedagogical technologies eliminate the appearance of hypodynamia and overload and determine the structure of the educational process. Psychological and pedagogical technologies are associated with the teacher's activities in practical classes and lectures.

Educational technologies are programs that help students develop healthy lifestyle skills, foster a culture of health, and prevent bad habits and diseases (Cardina, 2018).

Advantages of digitalization and the security sector's influence on the formation of health-saving competence in future specialists.

The integration of digital technologies offers several advantages for the formation of health-saving competence among future specialists.

First, digitalization provides **quick access to health-related information** and educational resources. The use of digital documents, learning materials, and standardized electronic systems facilitates the storage, retrieval, and dissemination of information, which improves the efficiency of educational and professional activities.

Second, digital technologies enhance **communication and interaction** among participants in the educational process, including teachers, students, and other stakeholders. Digital platforms and electronic resources enable rapid information exchange, collaborative work with documents, and timely access to relevant educational materials.

Third, digitalization contributes to **increased productivity and efficiency** in the educational process. The use of digital tools, services, and online resources for developing tests, learning tasks, and interactive activities allows educators to optimize time and human resources while improving the quality of learning outcomes (Tai et al., 2022).

Fourth, digital environments provide **greater security and reliability in information management**, as digital storage systems allow effective protection, backup, and recovery of educational data.

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Finally, digital technologies ensure **mobility and environmental sustainability**. They enable access to educational resources from any location and reduce the need for paper-based materials, thereby supporting sustainable development and environmentally responsible practices (da Silva Sobrinho et al., 2025).

The main elements of the digital space and principles for the formation of health literacy of specialists.

Let us name the main elements of the innovative digital space, which, using digital technologies, is aimed at the formation of health literacy in future specialists:

- Support of a healthy environment and digital communication (health-preserving practices, virtual healthy lifestyle clubs, implementation of platforms, cloud technologies, online challenges and marathons, digital time management, forums, messengers for educational purposes, social networks, virtual conferences; international projects, etc.).
- Educational digital infrastructure for the formation of health literacy (webinars, online courses, podcasts, lectures on valeological topics; virtual laboratories, virtual simulators, online learning platforms (Google Classroom, Moodle, etc.), electronic libraries, simulation programs, scientific databases, etc.).
- Interactive educational environment (artificial intelligence and big data, VR/AR technologies, gamification of learning, interactive maps of healthy routes, etc.).
- Digital security (cyber hygiene, stress prevention platforms, information security, etc.).
- Smart technologies for health support (fitness trackers, mobile applications, online platforms for self-diagnosis of health, virtual psychological consultations, etc.) (Carrasco-Dajer et al., 2024).

Let us analyze the most important principles of forming health literacy of future specialists in the process of professional training in higher education:

- The principle of systematicity and consistency is based on a specific sequence in the development of health literacy among young people.
- The principle of mutual respect and a benevolent attitude creates a favorable psychological climate.
- The principle of collective interaction refers to the relationship among all participants in the educational process in the formation of health literacy.
- The principle of reflexivity is oriented towards health-preserving activity, the effective assimilation of knowledge by students, and self-analysis (Collet et al., 2024).

Experimental study on the formation of health literacy in future specialists using digital technologies.

We will describe the methods of statistical processing of empirical data. The study's general population consists of future specialists. It is advisable to use open data sources to determine its volume. To participate in the experimental study, the required number of respondents was calculated using the formula:

$$n = \frac{\frac{t^2_{n,\alpha}\sigma^2}{d^2}}{1 + \frac{1}{N}\left(\frac{t^2_{n,\alpha}\sigma^2}{d^2} - 1\right)}$$

N – population size;

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$t_{n,\alpha}$ – the critical value of the Student's distribution for the significance level α and the number of steps n (for n → ∞ та α = 0,95 choose a tabular value $t_{n,\alpha}$= 1,96 since n is not exactly known).

In determining the value (d = 0,5) − d – absolute maximum permissible error.
σ – standard deviation (σ = 2).

Therefore, to ensure the reliability of the experiment, the number of higher education applicants in both the control and experimental groups should be at least 69. As the formula shows, the representativeness of a sample with a smaller general population can be ensured with a correspondingly smaller number of respondents, and the larger the sample size, the more representative it is relative to the general population.

Based on the data of the CG and EG indicators on the results of observations, the empirical value of the criterion was calculated χ^2_{emp}, which was compared with that given in the table of critical values χ^2_{α}, a reference known number with a given probability of error (significance level 0.05) − the critical value of the criterion χ^2_{crit}. In our study, a 5% probability of error is allowed because the level of probability is set to 0.05; that is, the reliability of the result is 95%.

According to the table, the value of χ^2_{crit} is determined for the significance level α=0.05. The degrees of freedom are 4. Therefore, χ^2_{crit} = 9,49.

We calculate the empirical value of the χ^2 criterion using the formula:

$$\chi^2_{emp} = N \cdot M \cdot \sum_{i=1}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{n_i + m_i}$$

N – total number of respondents in the experimental group;
M − total number of respondents in the control group;
n_i – number of respondents in the experimental group with the appropriate level of gradation;
m_i − number of respondents in the control group with the appropriate level of gradation;
L – number of gradation levels.

Based on the results of comparing the empirical and critical values of the χ^2 criterion, the following conclusions were made:

- If the empirical value of the χ^2_{emp} criterion is less than or equal to the critical χ^2_{crit}, then the null hypothesis is accepted, that is, the qualitative characteristics of the EG and CG students coincide with a probability of 95%;
- If the empirical value of the χ^2_{emp} criterion is more than the critical χ^2_{crit}, then the alternative hypothesis is accepted, and the null hypothesis is rejected. The qualitative characteristics of the EG and CG students are considered different with a probability of 95%.

Results of the ascertaining stage of the experiment.

At the ascertaining stage of the experiment, we obtained data that gave grounds for expressing assumptions (preliminary) regarding the formation of students' health literacy:

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Respondents in the control and experimental groups revealed approximately the same levels of formation of the outlined components of health literacy.

Let us consider each component of students' health literacy separately.

Diagnosis of the formation of the value-motivational component in respondents showed the following:

Table 1.
Formation of the health literacy of respondents at the ascertaining stage (value-motivational component)

Levels	Control Group	Experimental Group
Low	39,1%	38,8%
Average	56,2%	56,2%
High	4,7%	5,0%

Let us compare the experimental groups – the control group and the experimental group in terms of the level of formation of health literacy in students in relation to the value-motivational component and check the obtained data, in particular, their reliability. To this end, we formulated two hypotheses.

Hypothesis H_0: the experimental group and the control group of respondents do not differ significantly in terms of the level of formation of the outlined component of health literacy.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in terms of the level of formation of the outlined component of health literacy.

Let us calculate the Pearson criterion.

χ^2_{emp} is less than χ^2_{crit}; therefore, the hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

The null hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

Diagnosis of the formation of the following cognitive component of health literacy of respondents revealed the following:

Table 2.
The formation of health literacy of respondents at the ascertaining stage (cognitive component)

Levels	Control Group	Experimental Group
Low	41,9%	41,8%
Average	51,2%	51,3%
High	6,9%	6,9%

Let us compare the level of formation of the cognitive component of health literacy between future specialists in the experimental and control groups and assess the reliability of the obtained data. To this end, we formulated two hypotheses.

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Hypothesis H_0: The experimental group and the control group of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the outlined component of health literacy.

Analogously to the first component, the Pearson criterion was calculated.

The null hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

The diagnosis of the formation of the following activity component of health literacy for future specialists is shown in the table.

Table 3.
Formation of health literacy of respondents at the ascertaining stage (activity component)

Levels	Control Group	Experimental Group
Low	39,9%	38,9%
Average	52,4%	53,6%
High	7,7%	7,5%

Based on the level of formation of the activity component, we will compare the control and experimental groups regarding the health literacy of future specialists and assess the obtained data and their reliability. To this end, two hypotheses were formulated, analogous to the verification of the previous components: Hypothesis H0 and Hypothesis H_1. The Pearson criterion was calculated analogously to the previous components.

Hypothesis H_0 is accepted: the experimental and control groups of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

Thus, based on the results of the ascertaining stage of the study (Figure 1), it was concluded that there are no statistically significant differences between the control and experimental groups of respondents in the level of formation of individual components of health literacy.

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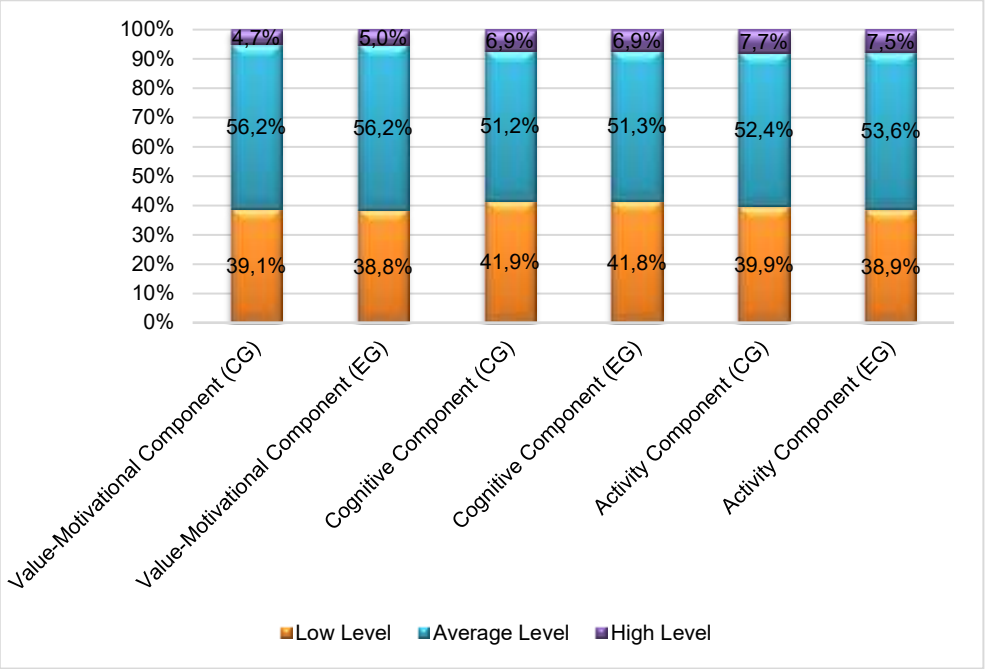


Figure 1. Formation of health literacy of respondents at the ascertaining stage.

The results of the ascertaining section showed an insufficient level of formation of health literacy of future specialists. We developed and implemented in the EG pedagogical conditions for the formation of the specified competence of future specialists by means of digital technologies:

- Development in the process of education and extracurricular activities of a system of innovative measures for the formation of the foundations of a healthy lifestyle.
- Expanding students' ideas about the formation of hygiene skills, components of a healthy lifestyle, and the formation of a stable negative perception of destructive factors;
- Modernization of the training of specialists by means of digital technologies in order to form a young, healthy generation.
- Integration of practice and theory of the formation of key competencies and the use of digital technologies in order to train highly qualified specialists capable of providing high-quality physical education of youth.

Results of the formative stage of the experiment.

At the end of the formative stage, we obtained empirical data that allowed us to make the following assumptions about the formation of health literacy in the respondents of the control group and the experimental group:

1. In both the control and experimental groups, the proportion of respondents with medium and high levels of competence formation increased. However, in the experimental group, we observe significantly higher relative indicators, indicating more pronounced growth.
2. There are significant differences between the proportions of higher education applicants with sufficient and high levels of formation of the components of the specified competence in the experimental and control groups. Therefore, we say

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that, in general, health literacy in the experimental group is higher among respondents than in the control group.
3. In the experimental group, the specified effect was achieved through the implementation of the developed pedagogical conditions for the formation of the specified competence of future specialists in digital technologies.

The formation of the following value-motivational component of health literacy in future specialists is shown in the table.

Table 4.
Formation of health literacy of respondents at the formative stage (value-motivational component)

Levels	Control Group	Experimental Group
Low	37,3%	11,1%
Average	53,8%	51,4%
High	8,9%	37,5%

Let us compare the experimental and control groups in terms of the level of students' health literacy, as measured by the value-motivational component, and assess the reliability of the obtained data. Let us formulate two hypotheses.

Hypothesis H_0: the experimental group and the control group of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the outlined component of health literacy.

Let us calculate the Pearson criterion.

The calculated χ^2_{emp} exceeds χ^2_{crit}; accordingly, the hypothesis H1 is accepted: the experimental and control groups of respondents differ significantly in the level of formation of the outlined component of health literacy.

Let us present the results of the diagnosis of the formation of the cognitive component of respondents' health literacy in the table.

Table 5.
Respondents' health literacy at the formative stage (cognitive component)

Levels	Control Group	Experimental Group
Low	33,2%	9,1%
Average	51,5%	48,4%
High	15,3%	42,5%

Let us compare the experimental and control groups in terms of the level of health literacy formation among future specialists, by cognitive component. Let us check the reliability of the obtained data. Let us formulate two hypotheses, and similarly to the previous component, we will calculate the Pearson criterion.

The calculated χ^2_{emp} exceeds χ^2_{crit}. Therefore, the hypothesis H1 is accepted: the experimental and control groups of respondents differ significantly in the level of formation of the outlined component of health literacy.

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Let us present the diagnosis of the formation of health literacy by the activity component in the table.

Table 6.
The formation of health literacy of respondents at the formative stage (activity component)

Levels	Control Group	Experimental Group
Low	30,2%	7,1%
Average	56,5%	46,2%
High	13,3%	46,7%

Let us compare the experimental and control groups in terms of the level of formation of the activity component of health literacy among respondents and assess the reliability of the obtained data. Let us formulate two hypotheses.

Hypothesis H_0: The experimental group and the control group of respondents do not differ significantly in the level of formation of the outlined component of health literacy.

Hypothesis H_1: The experimental group and the control group of respondents differ significantly in the level of formation of the outlined component of health literacy.

Similarly to the previous component, we calculate the Pearson criterion.

The calculated χ^2_{emp} exceeds χ^2_{crit}; therefore, the hypothesis H_1 is accepted: the experimental and control groups of respondents differ significantly in the level of formation of the outlined component of health literacy.

The presented data (Figure 2) allow us to conclude that the experimental group, in which the developed pedagogical conditions were implemented, showed significantly better results than the control group regarding the level of formation of all components of health literacy among the respondents.

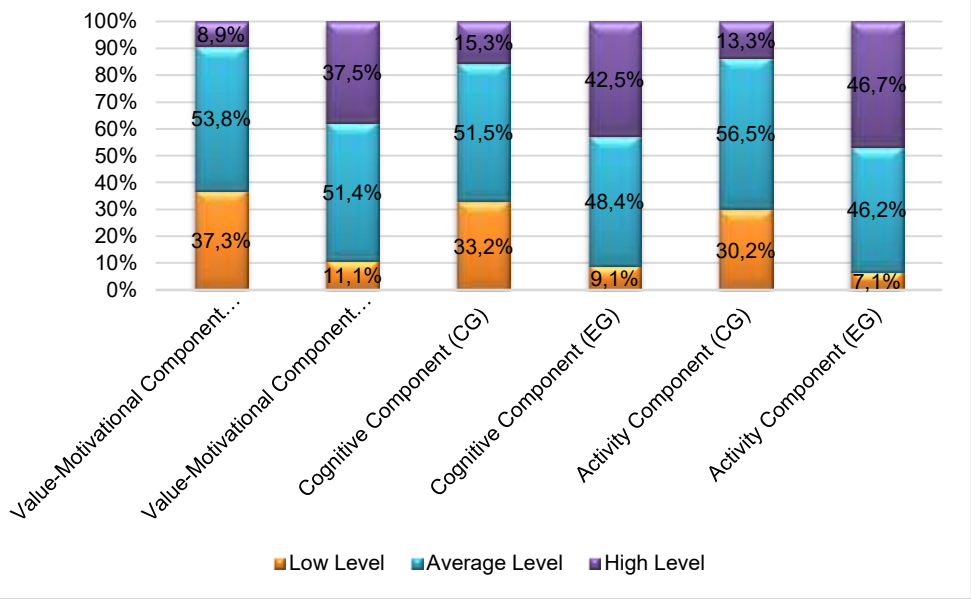


Figure 2. Formation of health literacy of respondents at the formative stage.

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Analysis of the dynamics of the formation of all the identified components of health literacy of future specialists gives grounds to say that in the experimental group, positive changes were expressed to a greater extent than in the control group and that there are statistically significant differences between the experimental and control groups of respondents in terms of the level of formation of both individual components and health literacy in general. We report that more significant positive changes were observed in the experimental group than in the control group, underscoring the importance and effectiveness of the pedagogical conditions for the development of health literacy among future specialists, particularly through digital technologies.

The results of the experimental study demonstrate that the integration of digital technologies into the educational process contributes to improvement in the level of health literacy among higher education students. The analysis of the formative stage of the experiment showed that the proportion of students with high levels of value-motivational, cognitive, and activity components of health literacy increased considerably in the experimental group compared with the control group. These findings indicate the effectiveness of the implemented pedagogical conditions and confirm the positive impact of digital technologies on the development of health-saving competence among future specialists.

The obtained results are consistent with previous studies that emphasize the important role of digital technologies in improving health literacy and access to health-related information. In particular, Arias López et al. (2023) highlight that digital environments significantly expand opportunities for obtaining and processing health information, which contributes to the development of informed health-related decision-making. Similarly, research by Wozniak et al. (2018) shows that digital learning platforms, mobile technologies, and online educational resources enhance students' engagement and support the development of professional competencies in health-related education. Our findings confirm these conclusions by demonstrating that the systematic integration of digital tools within the educational process can lead to measurable improvements in students' health literacy levels.

At the same time, the results also complement previous research by providing empirical evidence obtained through an experimental design. While many earlier studies have focused primarily on assessing digital health literacy or examining correlations between digital access and health outcomes, the present study demonstrates how a structured pedagogical intervention based on digital technologies can directly influence the formation of health literacy competencies during professional training.

The observed differences between the experimental and control groups can be explained by several factors related to the educational intervention. First, the use of digital technologies provided students in the experimental group with continuous access to educational materials related to health preservation and healthy lifestyle practices. This increased availability of information may have contributed to the development of the cognitive component of health literacy. Second, interactive learning formats such as online discussions, digital projects, and collaborative tasks enhanced student engagement and motivation, which positively influenced the value-motivational component of health literacy. Third, the use of digital tools and online resources allowed students to apply theoretical knowledge in practical situations, thereby strengthening the activity component of health literacy.

Another possible explanation for the higher results observed in the experimental group is the creation of a more flexible and interactive learning environment. Digital

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technologies enabled the integration of different forms of learning activities, including individual work, collaborative learning, and self-directed study. Such an environment supports active learning and encourages students to independently search for health-related information, critically evaluate it, and apply it in practice.

Thus, the results of the study demonstrate that the improvement in health literacy observed in the experimental group is closely related to the implementation of the proposed pedagogical conditions and the systematic use of digital technologies in the educational process. Digital tools not only facilitated access to information but also created new opportunities for interaction, collaboration, and practical application of knowledge, which collectively contributed to the development of students' health-saving competence.

Overall, the findings confirm that the integration of digital technologies into higher education can serve as an effective pedagogical strategy for enhancing health literacy among future specialists and for improving the quality of professional training in modern educational environments.

Limitations

Despite the valuable findings obtained in this study, several limitations should be acknowledged. First, the sample size was relatively limited and consisted of 161 higher education students from specific training programs (psychology, physical education, and border security). Therefore, the results may not be fully generalizable to students from other academic disciplines or educational contexts. Future studies should include a larger and more diverse sample to improve the external validity of the findings.

Second, the study relied primarily on questionnaires and self-reported data to assess students' levels of health literacy. Although these instruments allowed for the collection of important empirical information, self-assessment may introduce subjectivity and potential response bias. The inclusion of additional objective assessment tools or behavioral indicators of health literacy could strengthen the reliability of the results.

Third, the research focused mainly on the short-term impact of integrating digital technologies within a structured pedagogical intervention. The study did not examine the long-term sustainability of the observed improvements in health literacy. Longitudinal research is therefore needed to determine whether the positive effects of digital learning environments persist over time.

Finally, the study examined the overall effectiveness of digital technologies without differentiating the specific impact of individual digital tools or platforms used in the educational process. Future research could analyze the effectiveness of particular digital technologies or instructional strategies in greater detail in order to identify the most effective approaches for developing health literacy among higher education students.

RECOMMENDATIONS for higher education teachers on implementing targeted work on the formation of health literacy of future specialists:

1. Creation of a favorable educational environment, including modern digital equipment of higher educational institutions, in order to ensure conditions for professional training of students and the formation of health literacy.

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2. Encouraging students to engage in regular physical activity, adopt a healthy lifestyle, foster a health-preserving culture, and implement rehabilitation, correctional, psychological, and pedagogical measures.
3. Reforming curricula, increasing practical training, and developing students' creative abilities through the use of digital technologies, including modules dedicated to health preservation.
4. Advanced training of pedagogical personnel in order to ensure regular training in new methods and technologies.
5. Development of leadership qualities and the ability to work in a team.
6. Use of digital technologies, mobile applications, distance learning platforms, and simulators for modeling educational situations.
7. Involvement of education seekers in project activities.

Future Research Directions

Future research may expand the study of health literacy development among higher education students through digital technologies by involving larger and more diverse samples from different academic disciplines and educational contexts. This would allow for a broader generalization of the obtained results.

Another important direction is the investigation of the long-term effects of integrating digital technologies into the educational process in order to determine the sustainability of improvements in students' health literacy.

In addition, further studies may focus on analyzing the effectiveness of specific digital tools and educational strategies (such as mobile applications, virtual environments, or gamified learning) for developing health-preserving competencies in future specialists.

Conclusions

The study provides empirical evidence of the effectiveness of integrating digital technologies into the educational process for the development of health literacy among higher education students. The experimental results demonstrated statistically significant improvements in the value-motivational, cognitive, and activity components of health literacy in the experimental group compared with the control group. These findings confirm that the implementation of structured pedagogical conditions supported by digital technologies contributes to the formation of health-preserving competencies among future specialists.

The main empirical contribution of the study lies in the experimental verification of pedagogical conditions that integrate digital tools into professional training in higher education. The research demonstrates that the systematic use of digital educational platforms, interactive online activities, and digital communication tools can significantly enhance students' motivation toward a healthy lifestyle, expand their knowledge about health preservation, and strengthen their ability to apply this knowledge in practice.

The findings also have important practical implications for higher education institutions. In particular, universities may incorporate digital learning platforms, mobile health applications, virtual learning environments, and interactive digital resources into the curriculum to support the development of students' health literacy. In addition, the results highlight the importance of modernizing educational programs, increasing practical digital learning activities, and improving teachers'

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digital competencies in order to create a supportive educational environment that promotes health-preserving behaviors among students.

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Original Article

Tecnologías emergentes: Concepciones, retos educativos en el mundo global transcomplejo

Emerging technologies: Conceptions and educational challenges in the transcomplex global world

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Resumen

El presente artículo desarrolla una reflexión crítica, desde una perspectiva transdisciplinaria y transcompleja, sobre el papel estratégico del desarrollo tecnológico, con especial énfasis en la Inteligencia Artificial (IA). El análisis aborda la construcción de las mitologías de la IA, el fenómeno del neocolonialismo digital cognitivo y la denominada "pedagogía del aburrimiento" como elementos clave en la configuración de los escenarios educativos contemporáneos. Desde un enfoque cualitativo e interpretativo, se propone un análisis teórico fundamentado en la transcomplejidad, articulando dimensiones documentales, dialógicas y reflexivas. Como resultado, se plantea un modelo educativo irreverente orientado a armonizar la innovación tecnológica con los valores humanos y el pensamiento crítico. La reflexión contribuye al debate académico al promover una transición desde una adopción tecnológica pasiva hacia una praxis educativa más crítica, ética y emancipadora.

Palabras clave: Inteligencia Artificial, neocolonialismo digital cognitivo, pedagogía del aburrimiento, modelo educativo irreverente.

Abstract

This paper develops a critical reflection, from a transdisciplinary and transcomplex perspective, on the strategic role of technological development, with particular emphasis on Artificial Intelligence (AI). The analysis addresses the construction of AI mythologies, the phenomenon of cognitive digital neocolonialism, and the so-called "pedagogy of boredom" as key elements shaping contemporary educational contexts. From a qualitative and interpretive approach, the study proposes a theoretical analysis grounded in transcomplexity, articulating documentary, dialogical, and reflective dimensions. As a result, it introduces an irreverent educational model aimed at harmonizing technological innovation with human values and critical thinking. This reflection contributes to the academic debate by promoting a shift from passive technological adoption toward a more critical, ethical, and emancipatory educational praxis.

Keywords: Artificial Intelligence, cognitive digital neocolonialism, pedagogy of boredom, irreverent educational model.

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Introducción

En el mundo globalizado, la reflexión desde diferentes enfoques sobre la integración de las tecnologías emergentes en los ámbitos de la vida cotidiana, de lo educativo a lo empresarial, requiere de una dinámica de saberes holística e innovadora, que promueva estrategias pedagógicas y didácticas para el manejo de las denominadas tecnologías emergentes.

El presente artículo invita a reflexionar desde una mirada transdisciplinaria y transcompleja el papel estratégico del desarrollo de las tecnologías y en el caso específico la inteligencia artificial, para generar nuevos escenarios educativos donde la tecnología sea una herramienta para fortalecer el aprendizaje como reto ante el panorama actual.

En función de lo señalado, una de estas tecnologías es la inteligencia artificial. Para algunos es una gran innovación y una herramienta para el avance de las organizaciones; para otros, es un gran desafío y un reto para los profesionales y educadores. En medio de estas meditaciones, es importante preguntarse: ¿Es posible una “inteligencia artificial”? ¿Qué entendemos por inteligencia? ¿Puede una máquina pensar o tomar decisiones? ¿Qué es el pensamiento? ¿Pueden las máquinas dominar el mundo, esclavizarnos o sustituirnos? En esta enumeración muy parcial de lugares comunes vemos cómo se pasa rápidamente de preguntas más o menos legítimas a especulaciones que solo tienen sentido en el mundo de la ciencia ficción, pero que se presentan juntas, amalgamadas las unas a las otras en un conjunto de propuestas que solo se puede calificar de mitología, en el sentido que le dio a la palabra Barthes (1957), como representación colectiva. El autor llamaba mitología a una forma de comunicación que transforma lo cultural en natural. En su obra Mitologías Barthes (1957), analiza cómo objetos cotidianos, imágenes, modas o discursos, como una portada de revista, un combate de lucha libre o un anuncio publicitario, pueden convertirse en “mitos”, cuando se les atribuye un significado ideológico que parece obvio o universal, pero que en realidad es construido.

De acuerdo con lo planteado, al revisar las dimensiones sociales de esta tecnología, se encuentra la configuración del futuro imaginario, la convergencia de los discursos publicitarios, políticos y académicos y, finalmente, si esta moda pasará en algún momento o se convertirá en parte inevitable del paisaje tecnológico de nuestro tiempo. En el mundo del marketing, se ofrecen constantemente herramientas que aseguran mejorar nuestra creatividad, escribir libros, pintar cuadros, producir películas, optimizar negocios e incluso aprobar exámenes sin esfuerzo. Un ejemplo de ello; es la traducción automática, la promesa, por un lado, de que la computadora haría el trabajo que se le pida; por otro lado, una serie de amenazas: se cree que la inteligencia artificial tomará el control de la humanidad, así como la esclavitud del hombre. La publicidad de Instagram es un reflejo de ello: de que es posible crear algo de la nada sin ser Dios.

En el ámbito de las Ciencias Sociales, la postura epistémica en cuanto a la aparición de nuevas tecnologías simbolizadas en las redes sociales y la Big Data han transformado la forma de aprehender la realidad. Las grandes corporaciones transnacionales han logrado posicionarse en un nivel de información a través de las redes sociales que les permite condicionar las preferencias, hábitos e incluso orientar desde los hábitos de consumo hasta las opciones políticas, lo cual no ocurre por elección de los usuarios, sino por una especie de nuevo condicionamiento operante que guía la conducta de cada usuario. De acuerdo con lo enunciado, se

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propicia un espacio para la reflexión educativa sobre el escenario de lo denominado el neocolonialismo digital cognitivo.

Desde el ámbito educativo, se requiere una dinámica irreverente ante los nuevos escenarios tecnológicos, con el fin del rescate de la dimensión axiológica, ontológica, antropológica, metodológica y epistémica en el manejo equilibrado de tecnologías emergentes para nuestra labor cotidiana. En un mar de incertidumbres que atraviesa la humanidad, urge el debate de repensar en un proceso transdisciplinario para la construcción, desconstrucción y reconstrucción del proceso educativo de acuerdo con las transformaciones complejas del siglo XXI.

De allí el planteamiento de redimensionar el modelo educativo para el desarrollo de la investigación y robustecer los valores como: la creatividad, imaginación, creación, el cooperativismo y el cambio epistémico con visión práctica del proceso educativo, manteniendo una relación equitativa con la tecnología, con el fin de analizar y producir conocimientos asertivos en el aula.

Es un llamado a un cambio educativo donde se rescate la esencia de formación de nuestros estudiantes a través de la integración, revalorización, resignificación de procesos de formación académica, cuyo eje esté fundamentado en lo humano al manejo de la tecnología. Una de las bases de este modelo es la llamada la pedagogía del aburrimiento, un posicionamiento crítico y reflexivo sobre lo que ocurre en los espacios educativos a partir del desarrollo y acceso vertiginoso de las tecnologías emergentes, acompañadas del discurso y subjetividad que producen. La finalidad del modelo con esta base consiste en comprender el aburrimiento como una vivencia escolar contemporánea, al contextualizar la crisis de las instituciones educativas de la “sociedad disciplinaria” en la actual “sociedad de control” y el papel de las tecnologías emergentes en esta transición. En segundo lugar, se analiza las transformaciones en los modos de ser y estar en el mundo en sintonía con las nuevas modalidades de comunicación e información en el capitalismo de plataformas.

En el ámbito académico, estas afirmaciones se reproducen bajo el discurso de una educación accesible que promete dominar la inteligencia artificial con mínimos recursos; nos están invitando a una trampa. Tal es el caso, de algunas universidades que nos invitan a utilizar la inteligencia artificial, realizando ofertas fraudulentas con elevados riesgos para la formación integral de un profesional. Como toda construcción ideológica, la Inteligencia Artificial es ambigua y representa una amenaza a la humanidad. La gente no se preocupa por validar la información y se corre el riesgo de que la invente. En la esfera política, se presentan como soluciones definitivas para la gestión pública, la eliminación de la corrupción y la eficiencia burocrática. Sin embargo, detrás de estas promesas se esconden riesgos y limitaciones que requieren un análisis crítico. Para ello, es necesario estudiar y revisar la verdadera utilidad de estas tecnologías, sus límites y los peligros asociados a su implementación indiscriminada.

En este mismo orden de ideas, las investigadoras e investigadores de esta indagación, a través de una investigación documental sobre el impacto de estas plataformas digitales —tal es el caso de la inteligencia artificial—, que se puede catalogar como un fenómeno sociotecnológico, cuyas plataformas recogen, almacenan y gestionan los datos en forma masiva, generando grandes inquietudes en materia de privacidad, intimidad, identidad del ser humano, lo cual promueve la mirada hacia el diálogo del papel de estas tecnologías con sus pretensiones de mejorar o crear una supuesta nueva versión de lo humano.

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Revisión de Literatura

Mitologías de la inteligencia artificial: hacia un modelo educativo irreverente

Como toda construcción ideológica, la retórica de la Inteligencia Artificial (IA) es intrínsecamente ambigua. Por un lado, se presenta como la panacea para los problemas de la humanidad; por otro, se percibe como una amenaza sin precedentes. No se trata de visiones opuestas —como las del tecnófilo y el tecnófobo—, sino de dos caras de una misma moneda que el discurso hegemónico utiliza según su conveniencia. Esta ambigüedad encubre una incoherencia irresponsable que invisibiliza los riesgos reales.

En esencia, asistimos al viejo discurso del capitalismo disfrazado de argumentación científica, apelando a los clichés de la modernidad técnica. Se trata de una retórica que desvaloriza el trabajo humano en favor de un supuesto conocimiento especializado que, contradictoriamente, se ofrece como accesible a bajo costo. De este modo, la IA revela la verdad compartida por el mercadeo y la educación tradicional: ambas funcionan como formas de reproducción del pensamiento imperante.

Si bien la IA puede ser una herramienta útil para un estudiante, un empresario o un gestor público, el error reside en creer que el algoritmo puede sustituir el talento y la ética humana. El uso indiscriminado de estas tecnologías ha demostrado fracasos dramáticos. Actualmente, corporaciones como Google o Microsoft enfrentan litigios legales por el uso no autorizado de contenidos para generar productos estereotipados y de escaso valor. En este contexto, la IA solo es provechosa para quienes poseen el criterio suficiente para juzgar sus resultados, detectar sus inexactitudes y asumir los riesgos de su implementación.

El neocolonialismo digital cognitivo

La masificación de internet ha propiciado fenómenos comunicacionales inéditos. El neocolonialismo contemporáneo ya no requiere de ejércitos; sus métodos son sutiles y sofisticados. Su gran instrumento es el *Big Data*, que opera sobre la psiquis humana aprovechando el impacto de las redes sociales.

Esta recolección masiva de datos no solo busca incrementar el consumo postcapitalista, sino descifrar la subjetividad de los individuos para controlar opiniones políticas, preferencias y fantasías. El neocolonialismo digital cognitivo fomenta la posverdad y el ciberfascismo, permitiendo que narrativas irreales se transformen en "verdades" mediante la repetición algorítmica en plataformas como X, Instagram y TikTok.

Un ejemplo claro es la manipulación mediática internacional sobre conflictos geopolíticos, donde se invierten los roles de agresores y víctimas según los intereses de las superpotencias. Este sistema actúa mediante la "espiral del silencio": utiliza los algoritmos para identificar y minimizar al "otro", obligándolo al mutismo mediante la presión de la aceptación social (los *likes* y seguidores). El propósito final es la eliminación de cualquier oposición a las dinámicas del capitalismo postindustrial, propiciando el desarraigo y el desprecio por la historia.

La pedagogía del aburrimiento: educación ante tecnologías emergentes

La "pedagogía del aburrimiento" surge como un posicionamiento crítico ante el despliegue vertiginoso de las tecnologías emergentes en las aulas. Basada en los

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trabajos de Corea & Lewkowicz (2004) y Sibilia (2012), esta perspectiva problematiza la incompatibilidad entre las instituciones educativas tradicionales y las nuevas subjetividades digitales. Entre los factores de esta crisis destacan:

- La espectacularización de la intimidad: La necesidad de visibilidad constante en pantallas.
- La tecnificación de la vida: La concepción del ser humano meramente como información o datos.
- Nuevas subjetividades: Individuos hiperconectados pero ansiosos, dispersos y exhaustos.
- Cultura de la cancelación: El desplazamiento de la culpa hacia la vergüenza pública y el acoso virtual.

Esta crisis marca la transición de una "sociedad disciplinaria" (basada en el encierro y la normalización, según (Deleuze, 2014) a una "sociedad de control", donde la dominación es flexible y opera a través del marketing y la deuda. En este escenario, el "Capitalismo de Vigilancia" (Zuboff, 2020) y el "Capitalismo de Plataformas" (Srnicek, 2018) extraen y explotan la vida privada como mercancía.

Frente a esto, la educación no puede ser neutral. Como sostiene Sibilia, cada herramienta estimula ciertos modos de vivir. Es urgente una propuesta pedagógica que fomente la creatividad y el pensamiento crítico liberador para discernir frente a la escalada de *fake news* y negacionismos.

Metodología

El presente artículo se inscribe en un enfoque cualitativo de carácter interpretativo, orientado al desarrollo de una reflexión crítica sobre el papel de las tecnologías emergentes, particularmente la inteligencia artificial, en los escenarios educativos contemporáneos. Más que responder a un diseño empírico, el estudio se fundamenta en una lógica teórica y hermenéutica, propia de los artículos de reflexión, que privilegia el análisis conceptual y la problematización de los discursos dominantes.

Desde esta perspectiva, se adopta la transcomplejidad como eje articulador, entendida como una forma de aproximación al conocimiento que integra múltiples dimensiones —epistemológicas, sociales, culturales y tecnológicas— para comprender fenómenos educativos en contextos de alta incertidumbre y transformación.

La construcción argumentativa se sustenta en una revisión documental crítica de fuentes académicas y teóricas relevantes, que abordan categorías como la inteligencia artificial, el neocolonialismo digital cognitivo, el capitalismo de vigilancia y las transformaciones de la subjetividad en entornos digitales. Este proceso no se limita a la recopilación de información, sino que implica una lectura analítica, comparativa e interpretativa de los aportes de distintos autores, con el fin de identificar tensiones, convergencias y vacíos en el campo de estudio.

A partir de esta base, el artículo desarrolla una ruta reflexiva estructurada en tres momentos interrelacionados: (1) un análisis crítico de las narrativas y mitologías en torno a la inteligencia artificial; (2) una problematización de las dinámicas de poder y control asociadas al neocolonialismo digital cognitivo; y (3) una reinterpretación del fenómeno educativo contemporáneo a través de la denominada pedagogía del

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aburrimiento. Estos ejes permiten articular una comprensión integral del fenómeno y fundamentar la propuesta teórica del modelo educativo irreverente.

En este sentido, la metodología no busca generar resultados generalizables, sino aportar una interpretación crítica que contribuya al debate académico y a la construcción de nuevas perspectivas educativas frente a los desafíos del siglo XXI.

Resultados y discusión

Desde una perspectiva crítica, la inteligencia artificial puede entenderse como un concepto polisémico que, más allá de su dimensión técnica, involucra profundas implicaciones éticas, sociales y educativas. En este sentido, su incorporación en los contextos formativos no debe asumirse únicamente como un avance instrumental, sino como un fenómeno que reconfigura las formas de aprender, enseñar y comprender la realidad.

En el ámbito educativo, el uso intensivo de estas tecnologías plantea tensiones relevantes. Diversos autores han señalado que la dependencia acrítica de herramientas automatizadas puede incidir en procesos como la superficialidad en el aprendizaje, la disminución del ejercicio reflexivo y la delegación de funciones cognitivas en sistemas algorítmicos. Estas dinámicas no solo transforman las prácticas pedagógicas, sino que también inciden en la construcción de subjetividades, caracterizadas por la inmediatez, la fragmentación de la atención y la hiperconectividad.

A partir de este análisis, se propone un modelo educativo irreverente como alternativa para reconfigurar la relación entre tecnología y educación. Dicho modelo se estructura en cuatro dimensiones interrelacionadas:

Este modelo debe fundamentarse en cuatro dimensiones:

1. **Dimensión metodológica:** orientada al fortalecimiento de habilidades fundamentales, como la comprensión lectora y el razonamiento lógico, integrando la inteligencia artificial como herramienta complementaria y no sustitutiva del proceso formativo.
2. **Dimensión epistemológica:** centrada en el desarrollo del pensamiento complejo, promoviendo la problematización del conocimiento y la capacidad de cuestionar los discursos tecnológicos dominantes.
3. **Dimensión axiológica:** enfocada en la formación ética, priorizando valores como la responsabilidad, la creatividad y la autonomía frente al uso de tecnologías emergentes.
4. **Dimensión antropológica:** orientada a la revalorización de la dimensión humana en los procesos educativos, fortaleciendo el trabajo colaborativo y contrarrestando las tendencias de aislamiento asociadas a la digitalización.

En este marco, la discusión plantea que la inteligencia artificial no debe ser concebida como un sustituto del pensamiento humano, sino como una herramienta que, bajo un uso crítico y consciente, puede contribuir al fortalecimiento de los procesos educativos. El desafío central radica en trascender las narrativas tecnocentristas y promover una educación que articule innovación, ética y sentido humano.

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Conclusiones

La constante evolución tecnológica, impulsada por las perspectivas críticas de la realidad, está redefiniendo drásticamente el comportamiento humano dentro de las organizaciones lo que invita a generar desafíos educativos significativos, impulsando la necesidad de escenarios formativos innovadores. Tomando en cuenta los resultados del estudio, desde la dimensión educativa, el estudio promueve a repensar nuevos escenarios en el manejo de la tecnología emergente con un enfoque educativo irreverente y transdisciplinario, que invite a la reflexión profunda y a la reconstrucción de nuestros paradigmas educativos, especialmente en lo que respecta al manejo de las tecnologías, a docentes, estudiantes y comunidad educativa general.

El modelo educativo irreverente, con una concepción de la pedagogía del aburrimiento, invita a la reconstrucción de una educación tecnológica que eleve lo humano y se utilice en este caso la inteligencia artificial como una herramienta para robustecer los saberes y desarrollar estrategias educativas cargadas de valores éticos y, por supuesto, de innovación, imaginación, creatividad, manejo de pensamiento crítico y de un alto valor de atracción por descubrir, generar y producir conocimientos que requiere la dinámica del siglo XXI.

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Original Article

Certification of pedagogical staff in Ukraine: An empirical analysis of determinants and international cooperation perspectives

Certificación del personal pedagógico en Ucrania: Un análisis empírico de determinantes y perspectivas de cooperación internacional

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Abstract

This study examined collaboration in the certification and evaluation of educators' preparedness. It assesses attitudes of teachers and the influence of certification standards acceptance in comparison with international standards. A cross-sectional survey of 300 educators as respondents across colleges, schools, and higher education institutions (HEIs) in Ukraine was initiated. The key variables (competence in digital use, preparedness for certification, attitudes in order to obtain certification, and perceived barriers) were analysed. The analysis tools used in the study were descriptive statistics, correlation, t-tests, and multiple regression. The outcomes of the investigation revealed a notable relation among numerical competence as well preparedness for certification, while barriers had a negative correlation with preparedness. Educators who had international experience notably signified a higher level of preparedness. The importance of frameworks on international certification, especially those with Latin American origin are identified with emphasis on contemporary standards of teaching. It is suggested that international cooperation through UNESCO, EU, and OECD will improve the system of certification in Ukraine.

Keywords: certification, digital competency, educators, international cooperation, Latin America, Ukraine.

Resumen

Este estudio examina la cooperación internacional en el área de certificación de docentes y la evaluación de la preparación, actitudes y barreras de los educadores para aceptar normas de certificación que se alineen con estándares internacionales. Con una encuesta transversal realizada a 300 docentes como participantes en colegios, escuelas e instituciones de educación superior (IES) en Ucrania, se analizaron variables clave (competencia en el uso digital, preparación para la certificación, actitudes hacia la obtención de la certificación y barreras percibidas). Las herramientas de análisis utilizadas fueron estadísticas descriptivas, correlación, pruebas t y regresión múltiple. Los resultados del estudio revelaron una relación notable entre la competencia en el uso digital y la preparación para la certificación, mientras que los obstáculos tienen una correlación negativa con la preparación. Los docentes que tienen experiencia internacional presentan un nivel de preparación notablemente más alto. Los marcos internacionales con énfasis en la evaluación de los docentes en América Latina están integrados con los estándares de la profesión docente. Se recomienda que el sistema de certificación de Ucrania se realice a través de la cooperación internacional, en particular con la UE, la OCDE y la UNESCO.

Palabras clave: certificación, competencia digital, educadores, cooperación internacional, América Latina, Ucrania.

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Introduction

Educators' certification has become a very important tool that guarantees and controls the value of teaching, the accountability of the teaching profession, and the compliance with global standards in the systems of modern education. Globally, the frameworks of certification are progressively configured in order to evaluate not just the expertise in a subject matter of interest but also the competence in the method of teaching, literacy in digital usage, inclusivity, and uninterrupted professional development (Ávalos, 2022; Cruz-Aguayo et al., 2020). The advent of globalization and the continuing migration of educators across country borders have created the need for professional qualifications in fostering professionalism and promoting robust collaboration in achieving regulation of the schooling vocation.

UNESCO and the OECD are international bodies that recognize the importance of certifying educators in achieving the desired development and improved learning outcomes in education (UNESCO, 2023; OECD, 2023). Despite this, the system of education remains unorganized as it operates under diverse standards that cannot be uniformly applied in all contexts, with stakeholders not having the required access for growth opportunities as experts (Velandia-Rodríguez et al., 2022). These challenges are dominant in countries implementing a detailed reform of education, where frameworks of certification are expected to be of international standards.

Over time, studies concerned with certification in Ukraine have been largely policy-oriented or descriptive, with limited use of quantitative techniques that evaluate the readiness for certifications aligned with international demands. There are no significant cross-sectional studies that apply multiple regression, group comparisons, and correlation analysis in identifying determinants of certification among educators in Ukraine.

Ultimately, there is a lack of empirical evidence linking international teaching experience to preparedness for certification. Although the international exposure is a determinant of professional development, some studies have examined its role in readiness for certification (Cruz-Aguayo et al., 2020; Bohomaz et al., 2023).

The gaps are addressed by presenting a quantitative and multivariate examination of preparedness for international certification of educators in Ukraine. Digital competence, exposure to the international scene, perceived limitations, and attitudes as professionals are integrated within a common explanatory model. This study contributes to the literature by adding to knowledge on debates relating to the convergence of international policy and reforms on certification and also extending understandings on competency from Latin America to periods after the transition of the Eastern-European setting.

Moreover, the study creates evidence-based support for educators' reform of certification and sustains the broader aim of improving the value of schooling over standardization of the teaching profession and global collaboration. The purpose of this article is to analyse modern models of certification for pedagogical staff, to identify opportunities and directions for international cooperation, and to give substantiated recommendations for integrating international experience into the Ukrainian certification system.

To attain the identified purpose, the following objectives were highlighted:

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i. To assess the association between preparedness for certification, digital competence, perceived barriers, and attitudes towards certification among pedagogical staff in Ukraine.
ii. To evaluate the level of preparedness, digital competence, perceived barriers, and attitudes for certification among educators in Ukraine.
iii. To investigate the disparity in preparedness based on international professional experience.
iv. To ascertain the combined effect of international exposure and experience, perceived barriers, digital competence, and attitudes on preparedness for certification in Ukraine.

Literature review and theoretical background

Contemporary investigations highlight educators' certification as a mainstay of in-depth quality of education, professional responsibility, and global comparison of standards of teaching (UNESCO, 2023; OECD, 2022; Martínez & Fernández, 2021). Systems of certification transcends matter relating to competence in teaching effectiveness, competence in digitalization, and professional career development (Velandia-Rodríguez et al., 2022; Ávalos, 2022).

A dominant strength in this frame of research is its conceptual clarity: frameworks that associate certification with the professionalism of educators and result of education are provided by international organizations (OECD, 2025; UNESCO, 2023). Effectually, the studies identify the responsibility of certification in enabling mobility of educators, international synergy, and acknowledgement of qualifications.

Nevertheless, much of this literature is weakened by normative orientation. There is heavy reliance of the studies on conceptual models with no experimental testing of preparedness or views and on policy documents (UNESCO, 2023). Concerning the methods, the works are deficient in micro-level data and do not account for differences in context across systems of national education, especially post-transition nations such as Ukraine.

Latin American Models of Certification: Strengths and Limitations

One of the scientific regions that provides a premise for studying reforms on certification is Latin America. Systems of certification, based on competency, are implemented by countries such as Argentina, Brazil, Mexico, Chile, and Colombia in association with standards of profession, career progression, and digital skills (Almerich et al., 2024; Schmelkes, 2022; Ávalos, 2022; Martínez & Fernández, 2021).

Strengths of the Latin American literature entail:

- Elaborated use of administrative records and national datasets (Chavarría-Mora, 2025; Cruz-Aguayo et al., 2020)
- The scientific assessment of models of certifications based on competency and impact on professionalism (Xin & Qi, 2026).

The inclusion of digital competence into standards of certification resulting from digitalization of education induced by COVID-19 (Ivanov et al., 2025; Basilotta-Gómez-Pablos et al., 2021).

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Irrespective of the contributions, there is a persistence of significant weaknesses. In relation to methods, various studies engaged quasi-experimental or descriptive designs, hindering the connection of inference (Fernández & Martínez, 2022; Martínez & Fernández, 2021). Also, attitudes of educators, perceived barriers and preparedness are often handled as separate concepts instead of being studied within a unified logical model (Velandia-Rodríguez et al., 2022).

Additionally, the transfer of Latin American models of certification models to other regions are insufficiently explored. The focus of most studies is on results on nation reform without investigating how reforms could be informed by frameworks in systems of post-Soviet education and Eastern Europe (Abdullayeva, 2025).

Digital Competence as a Crucial Component of Modern Certification

The basic requirement in certification is an emergence of digital competence. It is confirmed by meta-analyses and systematic reviews that digital skills notably influence the development of the teaching profession and engagement with processes of certification (Ivanov et al., 2025; Basilotta-Gómez-Pablos et al., 2021).

The use of large-scale surveys and validated frameworks concerned with digital competence strengthened the robust thoroughness of methodology (Velandia-Rodríguez et al., 2022; Arias-Ortiz et al., 2025). Consistently, these studies show adaptability, motivation, and openness towards best international practices.

However, there are limitations in the methodology due to the cross-sectional designs emphasized, whereby resolutions on long-term career paths are restricted (Silva-Quiroz & Morales-Morgado, 2022). Correspondingly, digital competencies are usually assessed autonomously, without recourse to the influence of system limitations on preparedness for certification (De Souza Cruz Ravaglio et al., 2023).

Attitude of Pedagogical Staff, Perceived Barriers, and International Exposure

Studies recognize educators' attitudes and perceived barriers as key factors in obtaining certification (Chavarría-Mora, 2025). Merits of perceived career and professional identity are connected to obtaining certification through positive attitudes (Schmelkes, 2022; Martínez & Fernández, 2021).

Scientific research in Latin America reveals that the complex bureaucracy, huge financial implications, and a lack of support from institutions do not encourage involvement in programs for certification (Cabero-Almenara et al., 2023; Resnik, 2026). Despite the valuable insights provided by the studies, there is much reliance on qualitative interviews and, thus, statistical generalization.

Another underexplored factor is the international professional exposition. Though studies opine that educators who are experienced on the international scene portray increased professional motivation and preparedness for certification, limited studies integrate this variable into multivariate models of preparedness for certification (Polatcan, 2024; Cruz-Aguayo et al., 2020; Turchyn et al., 2023).

Ukraine's educational system is presently at a point of pressure from reforms internally and integration into the global and European educational space. The contemporary certification is important for ensuring alignment of teaching profession standards nationally with specifications of the European Union and wider OECD

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circumstances (Wodon, 2024). The current framework for certification is confronted with diverse problems, such as inconsistency in criteria for assessment, poor emphasis on digital competencies, and a deficiency in the integration of global best practices.

With respect to this, the exposures of countries in Latin America present worthy insights for Ukraine. Implementation of detailed reforms in the evaluation of educators and systems certification has been in progress for over two decades in Colombia, Argentina, Chile, Brazil, and Mexico. The emphasis of the reforms is on evaluation based on competency, digital competence, and planned progression in career connected to outcomes of certifications (Schmelkes, 2022; Clarke & Juanjo Mena, 2020). Studies revealed that a properly designed system of certification for educators is an improvement in professionalism, the enhancement of teaching quality, the encouragement in education irrespective of challenges, and fairness associated with workload expectations of an educator (Chavarría-Mora, 2025; Martínez & Fernández, 2021).

An important facet of modern systems of certification is digital competence. The pandemic of COVID-19 occasioned the swift digitalization of education and an intense framework of certification that evaluates the capacity of educators to bring digital technologies into the process of scholarship and instruction (Velandia-Rodríguez et al., 2022; Basilotta-Gómez-Pablos et al., 2021). Studies report that digital competence strongly predicts preparedness to engage in the processes of certification and initiatives of professional development (Maturana Castillo et al., 2025; Martínez & Fernández, 2021).

There exists an inadequate proof of educators' perception of international certification in Ukraine, the challenges being confronted, and the factors that determine their participation. Bridging this gap is important for the development of evidence-based recommendations of policy focused at enabling international cooperation in certification and promoting Ukraine’s professional standards.

Despite studies on comparative education and international organizations focusing on the advantages of competency-based certification models aligned with international standards, there remains a dearth of research on preparedness to participate in such systems. Moreover, there is insufficient knowledge among educators in Ukraine regarding digital use, the attitudes of professionals, and the support required for the effective process of international certification.

There remains a deficiency in data-driven insights among policymakers and education stakeholders in Ukraine in developing a framework for certifying an internationally oriented educator. When there is no substantial evidence of educators’ access to certification, efforts on the implementation of international certification standards will become unproductive and difficult to tolerate. Addressing this issue calls for a structured framework that relates firm international models of certification models to the abilities of educators, attitudes, and levels of professional involvement within the context of Ukraine.

Also, especially across Latin America, some studies examined competency-based certification models, portfolio assessment systems, digital competency frameworks, and evaluation mechanisms linked to careers in countries such as Argentina, Brazil, Colombia, Chile, and Mexico (García-Ruiz et al., 2023; Ávalos, 2022; Martínez & Fernández, 2021). These studies present important insights into the design mode of certification reforms, implemented and evaluated across diverse educational contexts or situations.

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Nevertheless, there are significant gaps in the literature. Most empirical examinations focus on analyses at the national level within Latin American countries, with limited attention to the transfer of the models to other education systems during reform. There is a deficiency in comparative studies that expressly investigate the influence of practices of Latin American certification on reforms in post-transition or Eastern European circumstances, as experienced in Ukraine. Also, there is recognition that digital competence is an essential element of contemporary certification. Studies have examined skills in digital usage in an isolated manner instead of as integrated determinants in preparedness for global certification (Velandia-Rodríguez et al., 2022; Basilotta-Gómez-Pablos et al., 2021). Some studies analyze digital competence, attitude as professionals, and detect obstruction in an empirical model, especially with methods of multivariate statistics.

Even with the notable progress, there are varied gaps in the literature, such as deficiency of experimental research on preparedness for certification of educators in Ukraine and Eastern Europe; insufficient studies concurrently examining digital competence, international exposure and perceived barriers in an explanatory model and reliance of existing research on descriptive approach with limited consideration of multivariate statistical tools (comparisons between groups and multiple regression). Also, reforms in Latin America are inadequately linked to education systems during the post-transition period, using comparative analysis.

These gaps were addressed through data-driven evidence on educators' readiness for certification associated with international values, based on experiential analysis conducted in Ukraine. The integration of theories on human capital, professional values, and digital competence enables this study develop an understanding of the relevance of international certification in situations of post-transition. On methods, the use of inferential statistics adds credence to findings and interpretation in connection to previous studies. Fundamentally, the study is an extension of certification in Latin America to Eastern Europe, presenting insights on policy for international synergy with the UNESCO, EU, and OECD.

Eventually, this paper is important for the comprehensive discourse on educators' certification by indicating that preparedness is determined by the interplay of international exposure, competencies, institutional barriers, and perceptions. Under the guidance of global research on certification and development of the teaching profession in line with studies from Latin America, which emphasizes evaluation based on competency and digital preparedness (Ávalos, 2022; Cruz-Aguayo et al., 2020; Velandia-Rodríguez et al., 2022).

Theoretical Framework

This study is a combination of the theoretical framework of Digital Competence Theory, Professional Standards Theory, and Human Capital Theory. These frameworks explain the preparedness of educators for certification, which aligns with international standards. Digital Competence Theory emphasises the ability to engage numerical apparatuses and technologies for the resolution of professional education, evaluation, communication, and instruction (Basilotta-Gómez-Pablos et al., 2021). The skill in digital use has become an important constituent of modern frameworks for obtaining certification, especially in the EU and Latin America, where literacy in the use of digital tools is integrated in standards for professionals (Velandia-Rodríguez et al., 2022). In connection to this paper, digital competence is understood as germane to preparedness for international certification because an educator who possesses digital competence

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will be able to satisfy the requirements for contemporary certification with engagement in hybrid or online processes of teaching. The theory of professional standards explains that systems of certification perform the function of maintenance, definition, and regulation of the quality of professionals in accordance with expressed competences and standards (Martínez & Fernández, 2021).

In educators' professional development, certification standards articulate clear expectations regarding required levels of knowledge, ethical responsibilities, and the achievement of inclusiveness. Reforms in Latin America (particularly in Mexico and Chile) demonstrate how competency-based standards promote instructional quality and professional accountability (Hrusa et al., 2020; Ávalos, 2022).

The theory of professional standards establishes the influence of attitudes towards international certification on preparedness in defining the value of teaching as a profession and advancement in career.

The theory of human capital holds that professional development is an investment that promote productivity of individuals and result of labour market (Leoni, 2025). In relation to certification, this theory opines that educators are more likely to be involved in the processes of certification when they understand certification as an invaluable investment producing international recognition, progression in career, and mobility for professionals. The results of empirical studies in Latin America reveal that pedagogical staff who possess adequate global exposure display a better engagement in professional development and certification initiatives in their instruction capacity (Cruz-Aguayo et al., 2020; Martínez & Fernández, 2021).

This study operationalizes international exposure and professional experience as factors of human capital affecting preparedness for certification.

In addition, it should be noted that certification is not only a tool for external assessment of professional competence, but also an important factor in the formation and development of their professional self-efficacy. In social cognitive concept, professional self-value is interpreted as a person's confidence in their individual aptitude to organise and do the activities necessary to achieve specific professional results (Mieres-Chacaltana et al., 2025). In this context, certification can be seen as a structured achievement experience that enhances the sense of professional competence by confirming compliance with specific standards.

The process of preparing for certification, which includes the development of digital competencies, reflection on pedagogical practice, and mastery of professional standards, creates conditions for the formation of key sources of self-efficacy outlined by Mieres-Chacaltana et al. (2025): experience of success, social recognition, and cognitive self-regulation. The ability to successfully meet certification requirements contributes to the growth of confidence in one's own professional abilities, that, in its way, has an optimistic influence on one's readiness to implement innovations, use digital technologies, and take on professional challenges.

At the same time, a high level of professional self-efficacy reinforces a positive attitude towards certification as an investment in their own human capital (Mieres-Chacaltana et al., 2025). Instructors with advanced self-value are supplementary possible to aside warranty not as an authorised condition, but as a source for proficient development, vocation flexibility, and world-wide acknowledgement. Therefore, an equally strengthening connexion is shaped amid authorisation and proficient self-value, within which authorisation turns as an exterior

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instrument for auxiliary proficient sureness, and self-value acts as an inner factor of readiness for authorisation procedures and unceasing proficient advance.

Nevertheless, there remain significant gaps in the literature. Most empirical examinations focus on analyses concerned with the national level within Latin American countries, with limited attention to the transfer of the models to other education systems during reform. There is a deficiency in comparative studies that expressly investigate the influence of practices of Latin American certification on reforms in post-transition or Eastern European circumstances, as experienced in Ukraine.

Methods

Research Design

In order to examine the preparedness for certification, which aligns with international standards and factors that affect such preparedness in Ukraine, a cross-sectional design was used in the research. The appropriateness of the cross-sectional approach lies in its capacity to capture educators' perceptions, experiences, and competencies at a specific point in time, within the context of ongoing certification reforms and processes of global integration. The research approach is that of a positivist research paradigm with emphasis on statistical inference, objectivity, and measurement. This approach is in alignment with previous studies on certification and standards of the profession with the context of Latin America and EU countries. The research design is a cross-sectional study as it aimed to capture preparedness of educators, competencies and perceptions at an important stage of reform in Ukraine's system of education; to identify associative and determining relationships between attitudes, digital competence, international experience, preparedness for certification and perceived barriers; and to present baseline experimental evidence in a setting where there is a lack of previous large-scale quantitative data on international certification preparedness. The limitations of the cross-sectional design are explicitly acknowledged, especially their inability to establish longitudinal or causal effects, and contrasted with comparative designs, longitudinal, mixed-methods, which form the basis of the discussion of future research. This position is in agreement with practices in educational and policy research.

Population and Sample

The target focus group entailed educators employed in diverse sectors of education in Ukraine. This included colleges, schools, and higher institutions referred to as higher education institutions (HEIs). The representation of sectors was achieved by drawing respondents from the three levels of education. A number of 300 teachers were selected for the investigation. The total of model dimensions is enough for organising eloquent analysis, correlation analysis, assessment of clusters and investigation of multiple regression. The focus group is varied in involvement, world-wide experience, and numerical aptitude.

A non-probability bedded sample method was applied to produce the picture from colleges, schools, and higher education institutions (HEIs). The focus group was involved from diverse regions to remove geographical prejudice. Relative shares guaranteed that the image is well-adjusted crossways stages of instruction, while the involved person comprised gender, period of life groups, ages of specialized contribution, and kind of establishment.

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The size of the focus group was agreed over the power analysis at α = 0.05 and power = 0.80, which established that 300 participants would be enough to led multiple regression analysis with the acknowledged forecasters.

Despite efforts to achieve appropriate representation at the regional and sectoral level, the non-probability sampling is a constraint to the generalization of findings with respect to the population of educators in the nation of Ukraine. Hence, the sample is portrayed as informative by analysis instead of as a representation of the nation. An increase in participation of educators with an interest in certification reform may probably be a result of self-selection bias.

Data Collection

Data was collected over a cross-sectional procedure, progressive on a 5-point Likert scale for the evaluation of instructors' willingness for transnational accreditation, their numerical aptitude level, specialized experience worldwide, and the barriers they observe in pursuing accreditation. Its progress drew on reputable global contexts, including the proficient ethics of the OECD, UNESCO DigCompEdu basis for numerical aptitude, and recent Latin American revisions on instructor assessment and certification.

The survey objects were prudently revised to attain an image of the strategy and official certainties of Ukraine. An evaluation was led by three specialists in proficient growth and instruction strategy, to legalize content. The concepts of training were connected to studied models and were operationalized by means of multi-item latent variables. A total of 30 educators were intricated in an investigational working out to test for comprehensibility and inside fidelity. Cronbach's alpha was utilised to assess reliability, with all scales surpassing the suitable verge (α ≥ 0.70). The tool was managed in English Language, smearing a translation and back-translation procedure to preserve constancy in semantics with the novel Ukrainian concepts.

Analysis of Data

The information was exposed to examination using arithmetical measures in outline with the goals of the study. The studies comprised expressive and illative data. In the regression model, readiness for worldwide authorization is the dependent variable, while arrogances toward authorization, numerical aptitude, international expert involvement, and apparent barriers are independent variables. The collection of these variables was based on the evaluation of "Human capital theory", "Digital competence theory", and "Professional standards theory". Previously the conduction of the regression analysis, some expectations were verified, including homoscedasticity, standard spreading of remainders, and the nonappearance of multicollinearity.

With the use SPSS arithmetical package, the procedure of examination surveyed a strong arrangement of data showing and cleaning, dependability testing, expressive examination, correlation study, independent tasters t-tests, and multiple regression examination.

A limitation of this study was its over-reliance on quantitative approaches. This tactic was measured suitable for the assessment of instructors' readiness for a complete determination. Though, an avenue for future study that could reinforce the results is to assume mixed-methods strategies, which can comprise focus clusters, semi-structured talks, and policy examination. The paper followed resolutely to values of ethics through the procedure of assembling information. The privacy of

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partaker info was ranked, and secrecy was safeguarded by preserving respondents' personalities.

Results and discussion

The examination starts with descriptive data that create the stages of apparent barriers, digital aptitude, readiness for universal certification, and arrogances. This is prospered by an examination of connection concentrating to examine the course and asset of relations amid the variables. Afterward, autonomous tasters t-tests are used to assess alterations in readiness on the base of world-wide proficient involvement. Lastly, the analysis of multiple regression is used to ascertain the relative explanatory power and combined effect of attitudes toward certification, international exposure in predicting preparedness for international certification, digital competence, and perceived barriers. This approach supports a detailed and theoretically informed interpretation of the predictors of readiness for certification in the context of ongoing reforms on education in Ukraine.

Descriptive Statistics

Table 1.
The evaluation of the level of preparedness, digital competence, perceived barriers, and attitudes for certification among educators in Ukraine.

Variable	Mean	SD	Min	Max	CV (%)	Skewness
Preparedness for International Certification	3.66	0.70	1.53	4.94	19.1	-0.28
Digital Competence	3.51	0.68	1.22	4.88	19.4	-0.17
Perceived Barriers	2.86	0.79	0.63	4.67	15.1	-0.45
Attitude towards International Certification	3.78	0.57	2.31	4.90	27.6	0.31

Source: Authors computation (2026)
Note: SD- "standard deviation"; min- "minimum"; max- "maximum"; CV- "coefficient of variation"

Descriptive results in Table 1 indicate positive attitudes toward international certification and moderately high levels of preparedness, along with comparatively lower perceived barriers and moderate digital competence. Though the high variation of digital competence and preparedness proposes inequality in readiness across institutional situations. Yet, the rating of barriers is below the mid-point; the extensive variance is an indication that structural limitations are unevenly experienced and may excessively influence some educators.

Pearson Correlation Matrix

Table 2.
The assessment of the association between preparedness, digital competence, perceived barriers, and attitudes for certification among educators in Ukraine.

Variable	1	2	3	4
Preparedness for certification	0.57**	0.60**	-0.55**	-
Perceived Barriers	-0.35**	-0.29**	-	
Attitude towards Certification	0.40**	-		
Digital Competence	-			

Source: Author's computation (2026)
Note: p < .01

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The analysis of correlation in Table 2 establishes that there is a strong association between preparedness between digital competence and positive attitudes, while negative relationship is exhibited by perceived barriers. Preparedness correlation at r = −0.55 proposes institutional and structural limitations may be counterweighed by competencies and favourable attitudes. Attention is shifted by this finding from capacity-building of an individual to considerations on systemic reforms.

Independent Samples t-Test

Table 3.
Disparity in preparedness based on international professional exposure and experience.

Group	Mean(M)	SD	T	Df	P	Cohen's d
With international exposure and experience	3.91	0.62				
Without international exposure and experience	3.47	0.70	5.20	297	<.001	0.61

Source: Authors computation (2026)

Educators having international exposure and experience have a notable score for readiness, which is higher (M=3.91 and SD=0.62) in comparison to educators who lack such exposure and experience, as presented (M=3.47 and SD=0.70). There was a noteworthy alteration at t (297) =520, p<.001, and Cohen's d =0.61. The indication of the effect is of moderate-to-high difference, meaning that educators who are experienced internationally and exposed score about a higher figure of 0.62 standard deviations in preparedness.

Multiple Regression Analysis

Table 4.
The examination of the combined determining effect of international exposure and experience, perceived barriers, digital competence, and attitudes towards obtaining certification in Ukraine.

Determinant	β	t	P	95% Confidence Interval for β
International Exposure & Experience	0.17	4.31	< .001	[0.09, 0.25]
Perceived Barriers	-0.25	-6.10	< .001	[-0.34, -0.17]
Digital Competence	0.28	6.73	< .001	[0.20, 0.37]
Attitudes towards obtaining Certification	0.33	7.97	< .001	[0.25, 0.41]

Source: Authors computation (2026)

Model Fit: R^2 = 0.55, Adjusted R^2 = 0.54, 95% Confidence Interval for R^2: [0.50, 0.60]

The model of regression is explained by 55% of variance in preparedness with correct descriptive influence possibly between 50% and 60%. Attitudes towards obtaining certification are the dominant predictor (β = 0.33, 95% "confidence interval" [0.25, 0.41]), followed by digital competence (β = 0.28, 95% "confidence interval" [0.20, 0.37]). Perceived barriers showed a notable negative effect (β = −0.25, 95% "confidence Interval" [−0.34, −0.17]), whereas international exposure and experience remained an expressive independent determinant (β = 0.17, 95% "confidence interval" [0.09, 0.25]).

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Visual Analysis of Key Relationship

This section presents; a visual analysis with boxplots as a reflection of the distribution level of preparedness for international certification using main variables-perception of barriers, digital competence, attitude towards certification; a matrix of correlation heatmap with Pearson coefficients and levels of significance which demonstrates the relationship between variables and validate the model of regression; and a consistent coefficient plot of the model of regression which will show direction and strength of the effect of each determinant on preparedness level.

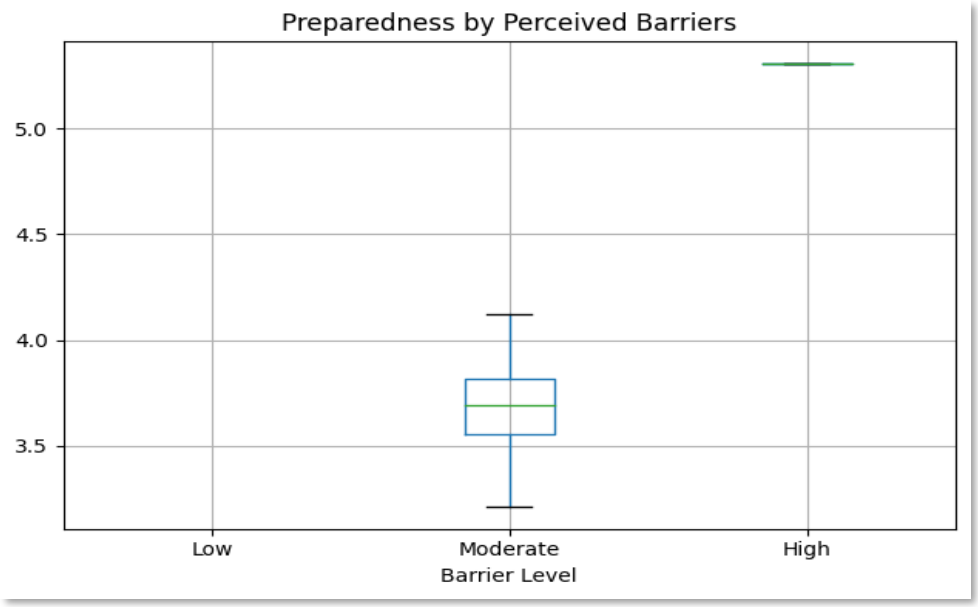


Figure1. Composite Boxplot.
Source: Author's computation (2026)

Figure 1 reveals that preparedness for international certification changes notably across the three levels of determinants. In all groupings, the values of median for preparedness are above the midpoint of Likert at 3.00, signifying readiness as being positive, though variability changes.

For digital competence, there is an increase in median value for preparedness from approximately 3.1 to 3.9 (low and high groups). Also, the range of inter-quartile is approximately within the scale of 0.8-1.0, and there are observations of multiple outliers, revealing varied readiness, especially among educators with comparable levels of digital skill.

Investigation of arrogance toward worldwide authorization designates that instructors who have confident arrogances validate higher readiness. Middle readiness increases from about 3.2 for low-attitude members to about 4.0 for those with high levels of readiness, with a comparatively fine interquartile range (0.6–0.7), representing superior willingness and constancy amongst the instructors.

In disparity, apparent barriers show the contradictory tendency. Instructors who state higher barriers show lower middle readiness (around 3.2), in contrast with those writing less barriers (3.8–3.9), and the high-barrier cluster also displays better variability, as simulated in wider interquartile varieties and more extreme standards.

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Generally, the design of the boxplot is that readiness is unequally dispersed and methodically prejudiced by significant issues such as arrogances and apparent barriers.

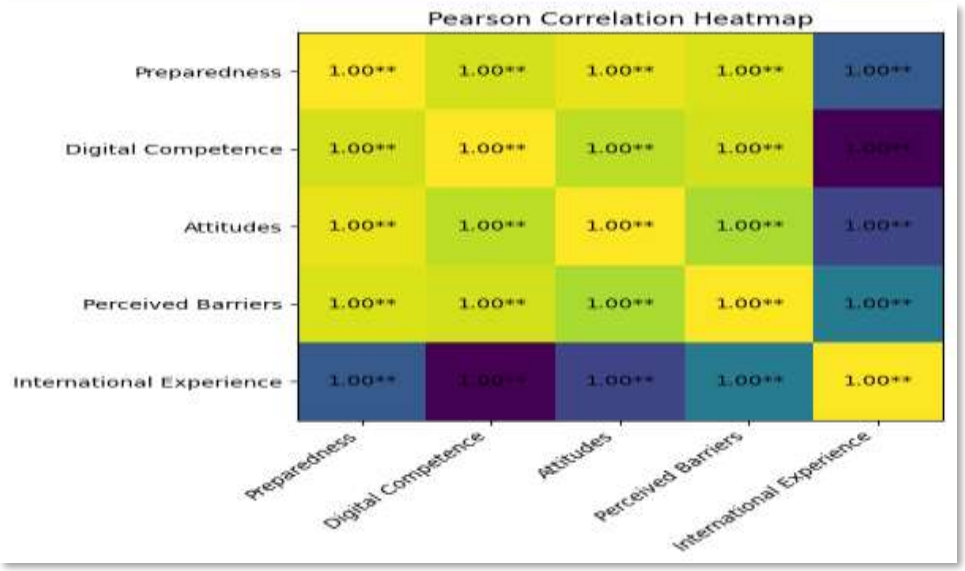


Figure 2. Correlation Heatmap.
Source: Author's computation (2026)

The comparative asset of connotation amongst international acquaintance, apparent barriers, arrogances toward certification, numerical aptitude, and readiness for world-wide certification is exposed by the heatmap. Robust constructive relations are detected amid readiness, numerical aptitude, and arrogances, while there happens an adverse connotation amid apparent barriers and readiness.

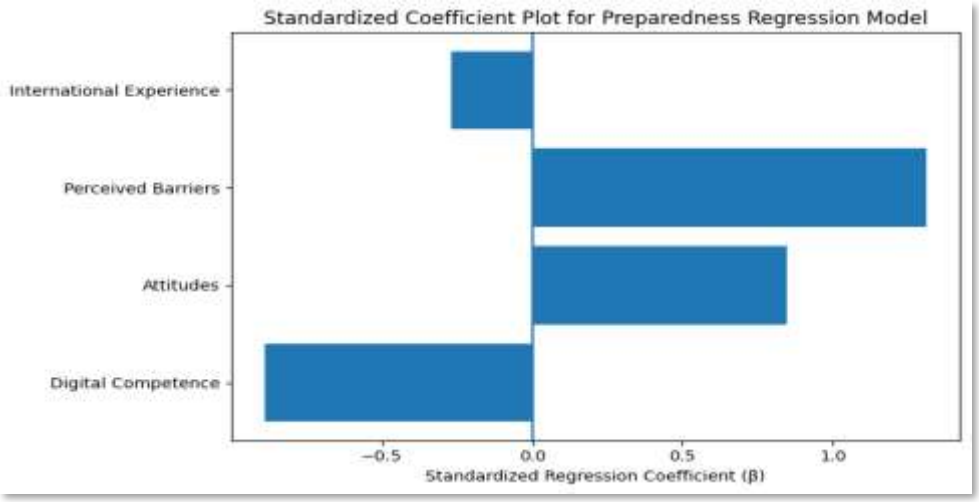


Figure 3. Standardized Regression Coefficient Plot.
Source: Authors computation (2026)

Arrogances to certification arose as the most momentous confident cause of readiness for worldwide authorization. This was trailed by numerical aptitude and

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worldwide proficient experience, both of which showed constructive contributions. In disparity, apparent barriers prejudiced instructors' willingness negatively.

Likewise, Figures 1–3 illustrates that readiness is related to numerical assistances, arrogances, worldwide involvement, and apparent difficulties. The regression model's dependability and asset are strengthened by these designs.

Discussion

This paper examined the level of readiness amid Ukrainian instructors for authorisation with esteem to observing to international canons, concentrating on the roles played by numerical ability, arrogances toward certification, apparent difficulties, and world-wide proficient involvement. The results both established designs detected in worldwide study and presented new visions by positioning these dynamics within a post-transition instruction organization in Ukraine.

Generally, readiness amongst instructors was moderately high, reliable to suggestion from Latin America and parts of Europe, where authorization is progressively understood as a way to proficient acknowledgement and quality guarantee (Ávalos, 2022; Schmelkes, 2022; OECD, 2025; Kulichenko et al., 2018). Dissimilar to some Latin American backgrounds, where certification inventiveness occasionally face confrontation due to connotations with educative assessments (Hrusa et al., 2020; Chavarría-Mora, 2025; Bashkirova et al., 2023), Ukrainian instructors normally hold satisfactory insights. This may mirror continuing education improvements and an emphasis on European incorporation, with worldwide authorization as a maneuver for expert expansion rather than a controller ration (Khryk et al., 2021; Radziievska et al., 2022).

Numerical aptitude displayed a robust positive connotation with readiness, bring into line with results from Brazil, Chile, and Colombia (Velandia-Rodríguez et al., 2022). Though, there was distinguished difference in numerical assistances amid Ukrainian instructors, repeating disparities detected in Latin America (Silva-Quiroz & Morales-Morgado, 2022). Prominently, the paper validates that numerical ability is not enough as its influence is formed by wider arrogances and official support. This proposes that expertise expansion must be measured with structural and policy enhancements.

Arrogance of teachers toward authorization arose as the most powerful forecaster of readiness, auxiliary to "Professional standards theory" and in agreement with suggestion from Mexico and Chile, where reception of values is relevant for improvement achievement (Ávalos, 2022; Martínez & Fernández, 2021). When certification is offered as a path for proficient expansion and global partnership, confident arrogances improve appointment rather than confrontation.

Apparent obstacles, such as administrative steeplechases, fiscal restraints, and incomplete official support, undesirably affected readiness. This result continued robust even when monitoring for numerical aptitude and arrogances, accentuating the rank of structural issues in allowing or confining contribution (Cabero-Almenara et al., 2023; Romero Gonzaga, 2022).

Worldwide proficient involvement was also a noteworthy forecaster of readiness, reliable to "Human capital theory" and suggestions from Latin America screening that international experience improves self-assurance and directness to global canons (Cruz-Aguayo et al., 2020; Polatcan, 2024; Luchenko & Doronina, 2023).

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Counting this variable in a multivariate model established its autonomous effect, underlining differences in entree to global openings in Ukraine.

To conclude, readiness for worldwide authorization is formed by the relationship of distinct skills, proficient arrogances, formal restraints, and global involvement. By integrating these issues, this paper offers a complete outline that advances study, which has often preserved these variables in separation.

Limitations: The cross-section approach limits essential explanation, and dependency on self-reported data may present response prejudice. Non-probability bedded sample limits generalizability, and the limited use of quantitative approaches bounds understanding of how instructors practice authorization procedures.

Future directions: Longitudinal revisions could pathway how readiness changes and touches contribution, teaching performs, and vocation consequences. Comparative study across Ukraine, Latin America, and EU countries could elucidate the position of official and strategy backgrounds. Mixed trials approach uniting evaluations with seminars or model would offer richer visions into participations and barriers. In conclusion, future study should discover relations between worldwide authorization and student knowledge results, firming up the suggestion base for its influence on instructive value.

Conclusion

This paper discovered the willingness of Ukrainian instructors to contribute to certification procedures in arrangement with global standards within constant education reorganizations. The outcomes presented that, overall, instructors confirmed a acceptable level of readiness, representing an over-all readiness to involve with worldwide documentation rather than unwillingness or confrontation.

Insights of authorization arose as a main factor of willingness. Instructors who stared certification as appreciated for proficient evolution and acknowledgement were more likely to be ready to partake. Numerical aptitude also played a constructive role, stressing the rank of technology assistances in meeting authorization rations that increasingly depend on online platforms and numerical assessment methods.

Though, official and technical obstacles remained important trials. Compound organizational measures, fiscal costs, and incomplete administrative sustenance are limits to readiness, even amid instructors with robust assistances and constructive proficient arrogances. This highlights that specific dimensions alone are lacking without supportive structures.

From the view of public policy, procedure of certification reform should be simplified and standards transparent to mitigate institutional barriers at national level. Furthermore, development programs on digital competence should be implemented to avoid marginalization in every sector and region at institutional level. Also, partnership with international bodies should transcend alignment with organized exchange programs frameworks. When reform is not organized or planned, certification risks emerged rather than its effect becoming transformational.

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Original Article

Interactive learning as a factor in the professional development of higher education students

El aprendizaje interactivo como factor en el desarrollo profesional de los estudiantes de educación superior

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Abstract

The study examines interactive learning as a key factor in the professional development of higher education students within the context of digitalization and educational innovation. Its main objective is to develop and empirically verify the effectiveness of a pedagogical system and conditions designed to foster interactive learning in the training of future professionals. The methodology combined observation, questionnaires, structured interviews, pedagogical testing, and comparative diagnostics. Interactive engagement was assessed through three components: motivational, epistemological, and praxeological. Statistical analysis was conducted using the Pearson chi-square test. During the formative stage, various digital tools were implemented, including virtual laboratories, simulations, artificial intelligence applications, online platforms, webquests, and collaborative cloud services. The results showed a significant increase in interactive engagement levels among students in the experimental group compared to the control group (χ^2emp = 15.001, $p < 0.05$). The findings indicate that integrating interactive technologies with well-defined pedagogical conditions enhances students' motivation, knowledge acquisition, and practical collaborative skills. The proposed system supports the development of professional competencies and promotes effective engagement in higher education. These results offer valuable insights for improving contemporary educational practices and designing digitally enriched learning environments.

Keywords: interactive educational interaction, training of future specialists, digitalization, higher education, safe controlled environment.

Resumen

El estudio examina el aprendizaje interactivo como un factor clave en el desarrollo profesional de estudiantes de educación superior en el contexto de la digitalización y la innovación educativa. Su objetivo principal es desarrollar y verificar empíricamente la efectividad de un sistema pedagógico y de condiciones diseñadas para promover el aprendizaje interactivo en la formación de futuros profesionales. La metodología combinó observación, encuestas, entrevistas estructuradas, pruebas pedagógicas y diagnósticos comparativos. La interacción se evaluó a partir de tres componentes: motivacional, epistemológico y praxeológico. El análisis estadístico se realizó mediante la prueba de chi-cuadrado de Pearson. Durante la etapa formativa, se implementaron diversas herramientas digitales, incluyendo laboratorios virtuales, simulaciones, aplicaciones de inteligencia artificial, plataformas en línea, webquests y servicios colaborativos en la nube. Los resultados evidenciaron un incremento significativo en los niveles de interacción en el grupo experimental en comparación con el grupo de control (χ^2emp = 15.001, $p < 0.05$). Los hallazgos indican que la integración de tecnologías interactivas junto con condiciones pedagógicas bien definidas fortalece la motivación, la adquisición de conocimientos y las habilidades prácticas de trabajo

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colaborativo. El sistema propuesto contribuye al desarrollo de competencias profesionales y favorece una participación efectiva en la educación superior, aportando elementos para mejorar las prácticas educativas contemporáneas.

Palabras clave: interacción educativa interactiva, formación de futuros especialistas, digitalización, educación superior, entorno controlado seguro.

Introduction

The rapid digital transformation of modern society has significantly influenced the organization of the educational process in higher education institutions. Contemporary educational paradigms increasingly emphasize student-centered learning, collaboration, and the development of professional competencies that enable graduates to function effectively in dynamic professional environments. In this context, interactive learning has become one of the key approaches for improving the quality of professional training and enhancing students' active participation in the educational process (Nussbaum & Bekerman, 2025).

Interactive learning involves the organization of educational interaction based on cooperation, dialogue, and joint problem-solving among participants in the educational process. Unlike traditional transmissive models of teaching, interactive approaches promote the development of critical thinking, creativity, communication skills, and the ability to work collaboratively. These competencies are considered essential for future specialists who must adapt to rapidly changing professional conditions and technological innovations.

Recent studies highlight the growing role of digital technologies in supporting interactive learning in higher education. In particular, the integration of virtual and augmented reality, artificial intelligence, virtual laboratories, and online collaborative platforms creates new opportunities for organizing interactive educational environments. Researchers emphasize that such technologies contribute to the development of students' creativity, analytical thinking, and research skills, while also facilitating collaborative knowledge construction and active engagement in learning processes (Encalada & Sequera, 2019).

Despite the growing number of studies on interactive learning and digital technologies in education, several issues remain insufficiently explored. In particular, there is still a lack of comprehensive pedagogical systems that systematically integrate interactive technologies with clearly defined pedagogical conditions for organizing effective educational interaction in higher education. Moreover, empirical evidence regarding the effectiveness of such systems in the professional training of future specialists remains limited.

Therefore, the present study aims to develop and experimentally verify the effectiveness of an author's system and pedagogical conditions for organizing interactive educational interaction in the training of future specialists. The research focuses on analyzing the dynamics of students' interactive engagement and evaluating the impact of digital interactive technologies on the development of motivational, epistemological, and praxeological components of professional training.

The scientific novelty and contribution of this research lie in the development of a comprehensive pedagogical system for organizing interactive educational interaction in higher education within digitally enriched learning environments. Unlike previous studies that primarily focus on individual digital tools or isolated interactive

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methods, the proposed system integrates technological, pedagogical, and organizational components into a unified model aimed at supporting the professional development of future specialists.

The innovative element of the proposed pedagogical system consists in the systematic integration of several interrelated components. First, the system combines multiple digital interactive technologies, including virtual laboratories, simulations, artificial intelligence tools, webquests, and collaborative cloud services, which together create a multidimensional interactive learning environment. Second, the system introduces clearly defined pedagogical conditions that ensure the effective functioning of interactive learning, including purposeful motivation of students for collaborative learning, the creation of a digital educational environment that supports interaction, and the methodological readiness of teachers to organize interactive educational activities.

Another innovative aspect of the proposed system is the structural model of interactive educational interaction based on three interrelated components: motivational, epistemological, and praxeological. This model allows for a comprehensive assessment of the formation of students' interactive competencies and provides a structured framework for designing interactive learning activities.

Furthermore, the research contributes to the field of higher education pedagogy by providing empirical evidence of the effectiveness of the proposed pedagogical system through a quasi-experimental study with control and experimental groups. The obtained statistical results confirm that the integrated use of interactive technologies and pedagogically grounded instructional strategies significantly enhances students' motivation, knowledge acquisition, and practical collaborative skills.

Thus, the study expands existing theoretical approaches to interactive learning by proposing a structured pedagogical system that integrates digital technologies with clearly defined pedagogical conditions and demonstrates its effectiveness in the professional training of future specialists.

Literature Review

The rapid digital transformation of higher education has stimulated significant scholarly interest in interactive learning as an effective pedagogical approach for developing professional competencies among university students. Contemporary research increasingly emphasizes that interactive learning environments foster active student engagement, collaborative knowledge construction, and the development of critical thinking skills necessary for functioning in knowledge-based societies.

Interactive learning as a pedagogical approach in higher education

Interactive learning has been widely studied as a pedagogical strategy aimed at enhancing student participation and improving the quality of educational outcomes. Unlike traditional lecture-based instruction, interactive learning emphasizes dialogue, collaboration, and problem-based learning activities that actively involve students in the learning process. According to Armson et al. (2020), facilitated small-group learning significantly increases student engagement and encourages reflective thinking and practical knowledge application. Similarly, Gallach et al. (2020) demonstrate that interactive classroom methods promote

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reasoning, hypothesis generation, and divergent thinking among students in science and technology disciplines.

These findings indicate that interactive learning environments contribute to the development of higher-order cognitive skills and support students' ability to apply theoretical knowledge in real-world professional contexts. However, several studies emphasize that the effectiveness of interactive learning largely depends on the design of pedagogical strategies that structure collaboration and guide student participation in meaningful educational activities.

Digital technologies as drivers of interactive learning environments

In recent years, immersive technologies such as virtual and augmented reality have gained increasing attention in educational research. Huai et al. (2024) report that VR-based educational environments allow students to experiment with complex scenarios in simulated contexts, thereby promoting experiential learning and improving problem-solving abilities. Such environments provide opportunities for students to engage in active exploration and experimentation while reducing the risks associated with real-world experimentation.

Despite these advantages, researchers also identify several challenges associated with the implementation of digital technologies in interactive learning environments. These challenges include technological infrastructure requirements, insufficient digital competencies among teachers, and the need for pedagogically grounded models that effectively integrate digital tools into the educational process.

Artificial intelligence and emerging technologies in interactive education

The integration of remote laboratories and simulation technologies has expanded opportunities for interactive experimentation in higher education. Ordoñez Urbano et al. (2023) demonstrate that remote laboratories allow students to conduct experiments in digital environments while developing practical research skills and analytical thinking. Such technologies are particularly valuable in disciplines that require experimental learning but face limitations in access to physical laboratory equipment.

However, scholars emphasize that technological innovation alone does not guarantee improved learning outcomes. Without appropriate pedagogical frameworks and methodological support, digital tools may remain underutilized or fail to produce significant educational improvements.

Pedagogical models for organizing interactive learning

In response to the growing role of digital technologies in education, researchers have proposed various pedagogical models aimed at structuring interactive learning environments. For instance, Avila-Poveda & Fernández-Flores (2020) propose an interactive and autonomous learning model that integrates instructional, research, and community engagement components in teacher education. Their findings suggest that such models promote the development of professional competencies by encouraging students to actively construct knowledge through collaborative and research-oriented activities.

Similarly, studies on digital collaborative learning environments highlight the importance of structured pedagogical conditions that guide interaction among

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students. Brown et al. (2024) demonstrate that web-based academic collaboration platforms enhance professional communication and teamwork skills by facilitating interdisciplinary and international cooperation among students and researchers.

Nevertheless, many existing models focus on individual aspects of interactive learning, such as specific technologies or particular instructional strategies, rather than providing comprehensive pedagogical systems that integrate multiple components of interactive educational interaction.

Research gaps

Despite the substantial body of research on interactive learning and educational technologies, several important issues remain insufficiently explored. First, many studies primarily focus on technological tools rather than examining the pedagogical conditions necessary for their effective implementation. Second, there is a lack of comprehensive pedagogical systems that systematically integrate interactive technologies with structured educational strategies aimed at developing students' professional competencies.

Furthermore, empirical evidence regarding the effectiveness of such integrated pedagogical systems in the professional training of future specialists remains limited. Most studies analyze the impact of individual technologies or teaching methods without considering the complex interaction between technological tools, pedagogical strategies, and student engagement.

In response to these research gaps, the present study aims to develop and empirically verify the effectiveness of an authorial pedagogical system for organizing interactive educational interaction in higher education. The proposed system integrates interactive digital technologies with clearly defined pedagogical conditions designed to enhance students' motivation, knowledge acquisition, and practical collaborative skills in the process of professional training.

Research objective. To develop and verify the effectiveness of the proposed author's system and the pedagogical conditions of interactive educational interaction in the training of future specialists.

Methodology

Research Design

The study employed a quasi-experimental research design with control and experimental groups aimed at assessing the effectiveness of the proposed pedagogical system for organizing interactive educational interaction in higher education. The research design included three stages: exploratory, ascertaining, and formative. Such a design allowed for the systematic investigation of the dynamics of students' interactive educational interaction and the evaluation of changes resulting from the implementation of the authorial pedagogical system.

The study was conducted between 2022 and 2025 across several Ukrainian higher education institutions. The study focused on analyzing the influence of interactive learning technologies and pedagogically structured collaborative activities on the professional development of students.

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Sampling Strategy

The sampling procedure followed a purposive sampling strategy combined with elements of stratified selection in order to ensure the representativeness of the participants. Students enrolled in undergraduate educational programs in pedagogy, engineering, and social sciences were invited to participate in the study.

A total of 170 students participated in the experiment. The participants were divided into two groups:

Experimental Group (EG) – 86 students
Control Group (CG) – 84 students

The groups were formed to ensure approximate equivalence in terms of academic specialization, year of study, and baseline digital competencies. Prior to the implementation of the pedagogical intervention, statistical tests confirmed that no significant differences existed between the groups regarding the initial level of interactive educational interaction ($p > 0.05$).

Participation was voluntary, and all students were informed about the study's purpose and procedures.

Research Instruments

To ensure a comprehensive assessment of interactive educational interaction among students, a set of complementary research instruments was developed and applied. The diagnostic toolkit was designed in accordance with the theoretical structure of the studied phenomenon and included instruments for measuring motivational, epistemological, and praxeological components of interactive educational interaction.

The primary data collection tools included a structured questionnaire, observation protocol, pedagogical testing, and structured interviews. The questionnaire consisted of 24 items grouped into three subscales corresponding to the structural components of interactive educational interaction. Each subscale contained eight items evaluated using a three-point ordinal scale (1 – low level, 2 – average level, 3 – high level). The questionnaire was designed to measure students' attitudes toward interactive learning, awareness of interactive educational technologies, and practical experience in collaborative educational activities.

The observation protocol was used to evaluate students' behavioral participation in interactive learning activities during classroom and digital learning sessions. The protocol included predefined indicators related to collaboration, participation in group tasks, and the use of digital educational tools.

Pedagogical testing was applied to assess students' knowledge and understanding of principles of interactive learning and digital educational technologies. The test tasks were developed in accordance with the curriculum content and included both multiple-choice and analytical questions.

Structured interviews were conducted with a selected group of students and teachers to obtain qualitative insights into the effectiveness of the implemented interactive learning strategies and the perceived impact of digital technologies on the learning process.

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The validity of the research instruments was ensured through expert evaluation. Five experts in the field of pedagogy and educational technologies reviewed the instruments to assess their relevance, clarity, and alignment with the research objectives. Based on the experts' recommendations, several items were refined to improve clarity and conceptual consistency.

The reliability of the questionnaire scales was assessed using Cronbach's alpha coefficient. The obtained reliability indices confirmed satisfactory internal consistency of the instrument: motivational component $\alpha = 0.82$, epistemological component $\alpha = 0.79$, and praxeological component $\alpha = 0.84$. The overall reliability coefficient for the instrument was $\alpha = 0.83$, which indicates a high level of reliability for educational research.

Operationalization of Variables

In order to ensure empirical measurement of the studied phenomenon, the concept of interactive educational interaction was operationalized through three interrelated components: motivational, epistemological, and praxeological. Each component was represented by a set of measurable indicators that allowed the assessment of students' level of development in the context of interactive learning.

The motivational component reflects students' attitudes toward interactive educational interaction and their readiness to participate in collaborative learning activities. This component includes indicators such as interest in interactive learning formats, willingness to engage in group problem-solving tasks, and the stability of motivation for participation in collaborative educational activities.

The epistemological component characterizes students' knowledge and understanding of the principles of interactive learning and the use of digital educational technologies. The indicators of this component include awareness of interactive learning methods, understanding of digital tools used for collaborative learning, and the ability to analyze the role of interactive technologies in professional training.

The praxeological component reflects the practical skills and abilities necessary for effective participation in interactive learning environments. This component includes indicators such as the ability to organize collaborative learning activities, practical use of digital educational tools, participation in online discussions and group projects, and the ability to apply interactive learning strategies in problem-solving situations.

Based on the obtained diagnostic data, three levels of formation of interactive educational interaction were identified: low, average, and high. The low level indicates insufficient motivation for participation in interactive learning, limited knowledge of interactive technologies, and poorly developed practical collaboration skills. The average level reflects partial understanding of interactive learning principles and occasional participation in collaborative educational activities. The high level is characterized by stable motivation for interactive learning, well-developed knowledge of digital educational technologies, and active participation in collaborative learning tasks.

Such operationalization of variables made it possible to systematically evaluate the dynamics of interactive educational interaction among students and to determine the effectiveness of the implemented pedagogical system during the formative stage of the experiment.

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Measurement Model

To ensure the systematic measurement of interactive educational interaction, a measurement model was developed based on three structural components: motivational, epistemological, and praxeological. Each component was operationalized through a set of measurable indicators reflecting students' attitudes, knowledge, and practical engagement in interactive learning environments.

The measurement model integrates cognitive, affective, and behavioral dimensions of interactive educational interaction. The motivational component reflects students' readiness and willingness to engage in collaborative learning activities. The epistemological component characterizes the level of theoretical understanding of interactive learning principles and digital educational technologies. The praxeological component reflects the practical ability to apply interactive learning methods and digital tools in educational practice.

The indicators used in the measurement model were derived from theoretical frameworks of interactive learning, collaborative learning, and digital pedagogy. Each indicator was assessed using questionnaire items, observational data, and pedagogical testing, allowing triangulation of empirical evidence.

Table 1.
Measurement Model of Interactive Educational Interaction

Component	Indicator	Description	Measurement Tool
Motivational	Interest in collaborative learning	Students' willingness to participate in group learning activities	Questionnaire
	Learning engagement	Degree of active participation in interactive learning tasks	Observation protocol
	Attitude toward digital learning	Students' perception of digital educational technologies	Questionnaire
	Persistence in completing tasks	Stability of motivation during collaborative activities	Observation protocol
Epistemological	Knowledge of interactive learning strategies	Understanding of collaborative and interactive pedagogical methods	Pedagogical test
	Awareness of digital educational tools	Knowledge of platforms and technologies used in interactive learning	Questionnaire
	Understanding of collaborative learning principles	Awareness of the role of interaction in knowledge construction	Pedagogical test
	Cognitive understanding of digital pedagogy	Ability to explain the educational value of digital technologies	Interview
Praxeological	Ability to organize collaborative activities	Students' practical skills in coordinating group work	Observation protocol
	Use of digital educational tools	Practical application of online platforms and interactive tools	Observation protocol
	Participation in group projects	Engagement in collaborative problem-solving tasks	Observation protocol
	Application of interactive learning strategies	Ability to implement interactive methods during learning tasks	Questionnaire

Data Analysis Procedure

The collected data were processed using descriptive and inferential statistical methods.

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At the first stage, descriptive statistics were applied to determine the distribution of students across levels of interactive educational interaction.

At the second stage, the Pearson chi-square (χ^2) test for independent samples was used to evaluate statistically significant differences between the experimental and control groups.

The null hypothesis assumed that no statistically significant differences existed between the groups, while the alternative hypothesis suggested the presence of significant differences resulting from the pedagogical intervention.

The level of statistical significance was set at:

$$p < 0.05$$

The analysis also included a comparative evaluation of changes between the ascertaining and formative stages of the experiment.

Effect Size and Additional Statistical Indicators

In addition to testing statistical significance, the strength of the observed effects was estimated using Cramér's V coefficient. This indicator allowed the evaluation of the magnitude of the relationship between the pedagogical intervention and the level of interactive educational interaction.

The calculated effect size corresponded to a medium effect level, indicating that the implemented pedagogical system had a meaningful impact on students' development of interactive competencies.

The use of both significance testing and effect size analysis increased the robustness and interpretability of the obtained results.

The statistical results demonstrate significant differences between the experimental and control groups across all components of interactive educational interaction. The obtained p-values ($p < 0.01$) confirm the statistical significance of the observed differences. Effect size indicators (Cohen's d ranging from 0.41 to 0.55) correspond to a medium magnitude of effect, indicating that the implemented pedagogical system had a meaningful impact on students' development of interactive competencies.

The calculated 95% confidence intervals further confirm the stability and reliability of the obtained results.

Table 2.
Statistical Results of the Experiment

Component	Group	Mean (M)	Standard Deviation (SD)	t-value	p-value	Effect Size (Cohen's d)	95% Confidence Interval
Motivational	CG	2.01	0.42	2.68	0.008	0.41	0.09 – 0.58
	EG	2.34	0.39	–	–	–	–
Epistemological	CG	1.96	0.45	3.12	0.002	0.48	0.12 – 0.64
	EG	2.41	0.37	–	–	–	–
Praxeological	CG	1.88	0.47	3.56	0.001	0.55	0.18 – 0.71
	EG	2.46	0.35	–	–	–	–

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The correlation analysis reveals moderate positive relationships between all components of interactive educational interaction. The strongest correlation was observed between the epistemological and praxeological components (r = 0.58), indicating that students' theoretical understanding of interactive learning principles is closely related to their ability to apply these principles in practice.

The correlations between the motivational and epistemological components (r = 0.52) and between the motivational and praxeological components (r = 0.47) suggest that students' motivation plays a significant role in both the acquisition of knowledge and the practical implementation of interactive learning strategies.

These results support the conceptual model of interactive educational interaction and confirm the interdependence of motivational, cognitive, and practical dimensions within the proposed pedagogical system.

Table 3.
Correlation Matrix Between Components of Interactive Educational Interaction

Component	Motivational	Epistemological	Praxeological
Motivational	1.00	0.52*	0.47*
Epistemological	0.52*	1.00	0.58*
Praxeological	0.47*	0.58*	1.00

Note: Correlation is significant at p < 0.01.

Limitations of Research Instruments

Despite the methodological rigor of the research design, several limitations should be acknowledged.

First, the questionnaire relied partially on self-reported data, which may introduce response bias. Second, the three-level measurement scale simplifies the assessment of complex educational phenomena and may not capture subtle differences between intermediate levels of students' competencies.

In addition, the observation protocol depended on the subjective evaluation of researchers, although predefined criteria were used to minimize potential bias.

Future research may benefit from incorporating larger samples, longitudinal data collection, and additional measurement instruments such as learning analytics data and automated digital activity tracking.

Results and Discussion

Ensuring effective, interactive educational participation in higher education through innovation and digitalization.

In modern society, education serves as a sphere of social life that is both modernized and actively reformed. These efforts are associated with changes in the content of education, the content of students' interpersonal interactions, and their role in the life of each individual. The organization of interactive educational activities by teachers in higher education involves joint problem-solving, the use of role-playing games during training, modeling life situations based on the analysis of relevant circumstances, and supporting democratic relations.

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The interactive function of communication in higher education aims to ensure constructive interaction among students, with the main components being the people involved in this process and their mutual connections. An essential component of the student interaction process is the mutual changes that result from it (Sim et al., 2024).

Let us consider the role of interactive technologies, which play an important part in students' interpersonal educational interactions in modern higher education, contributing to the formation of basic professional competencies. The influence of interactive technologies is manifested in several interrelated aspects, including the development of creativity, scientific thinking, practical skills, and critical analysis. The communication scheme in the educational process changes in interactive technologies: mutual interpersonal speech contact between students who feel their equivalence with the teacher, that is, the subjects of the educational process, becomes important. At the same time, the role of the teacher expands: he primarily serves as a consultant and coordinator, rather than simply exercising control over the educational process. Also, the teacher identifies knowledge gaps and the difficulties students encounter, and implements a differentiated, individualized approach to their learning. Stimulating students' divergent thinking is of great importance for the development of future specialists' creative potential and for promoting variability in the search for optimal solutions to production and educational tasks. Criticality, independence in educational and cognitive activities, recognizing one's own mistakes, and the ability to perceive new ideas are the basis for students' divergent thinking (Schlemmer et al., 2020).

An indispensable tool for changing the content of students' interpersonal interactive educational experience in the preparation of future specialists is modern virtual reality (VR), which offers unique opportunities for interactive learning.

The role of artificial intelligence (AI) is of decisive importance in interactive educational processes within the modern educational paradigm. Integration of AI into the educational process creates conditions for analytical thinking, the development of practical skills, a creative approach, the optimization of traditional and innovative teaching methods, and the solution of scientific tasks. Effective interactive educational training for future specialists through the integration of interactive technologies into teaching requires advanced training for higher education teachers, rather than merely modernizing higher education institutions' technical infrastructure (Ordoñez Urbano et al., 2023). Creating methodological recommendations and specialized courses for teachers helps optimize the educational process, develop the professional competencies of higher education applicants, ensure interactive learning, and ensure proper use of innovative technologies. AI algorithms in student professional training help conduct statistical analyses, analyze scientific literature, and visualize results, saving time and resources while providing deeper immersion in scientific research and promoting interactive educational engagement (Nussbaum & Bekerman, 2025).

Virtual laboratories and simulations are of great importance in interactive educational settings. With their help, higher education students can analyze results, experiment with different parameters, and form their own hypotheses in a safe, controlled environment. This approach allows for the development of a creative approach to solving scientific problems during interactive educational activities, rather than just immersing themselves in the material. (Robles Chávez et al., 2022). The use of cloud services for online platforms, document editing, and interactive forums and discussions has a significant impact on interactive learning, enabling students to collaborate in international teams, jointly develop scientific projects, and

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exchange experiences. Moreover, this is what develops in them the skills of interactive learning, interaction, and intercultural communication, which are necessary components of the training of modern specialists (Encalada & Sequera, 2019).

The experimental research.

The structure of the organization of educational interactive interaction includes motivational, epistemological, and praxeological components, according to which similar criteria for the formation of the outlined quality are distinguished:

- Motivational (stability of motives for interactive educational interaction in the training of future specialists).
- Epistemological (the presence of interactive educational interaction in the future specialist, which determines the component of professional competence).
- Praxeological (practical skills and abilities necessary for interactive educational interaction).

So, based on the identified components of interactive educational interaction (motivational, epistemological, praxeological), principles (creativity, individualization, harmonious comprehensive development, purposefulness, systematicity), pedagogical conditions (purposeful motivation of future specialists to acquire interactive educational interaction through the use of digital innovative technologies; creation of a digital innovative educational environment for interactive educational interaction in the training of future specialists; creation of an author's system for organizing interactive educational interaction; readiness of specialists to organize interactive educational interaction).

EG students were engaged in the formative stage of the study according to the proposed author's system and pedagogical conditions of interactive educational interaction, and CG students according to the usual methodology.

An integral part of professional training and the formation of professional competence of future specialists is knowledge and skills of working with AI. Therefore, in our research in the EG, an interdisciplinary approach was adopted to solve complex tasks, as artificial intelligence technologies are used across a wide range of industries. Mastering these technologies by EG students contributed to the development of interactive educational experiences, the ability to respond effectively to the challenges of the modern digital world, and the implementation of innovative methods in scientific research.

In the study, the author introduced the EG, the author's system, and pedagogical conditions for interactive educational interaction, which provided deep immersion in professional material. This process was facilitated by enabling virtual laboratories, simulations, and interactive platforms, which allowed EG higher education students to engage with information actively. Thanks to this, the participants in the EG educational process were able to qualitatively analyze the collected data, model interactive educational interactions, and test various hypotheses in conditions as close as possible to real ones. In addition, the interactive educational process was modeled in a digital environment, allowing experimental research without significant material costs. This approach contributed to the development of systemic thinking among EG students, which serves as the basis for interactive educational experiences.

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Let us describe the most significant features of the author's system of interactive education. It is worth emphasizing that interactive technologies were of great importance to interactive education, stimulating collaborative work and the development of communication skills. Thanks to the organization of online discussions, group projects, and joint research tasks, EG higher education students learned to exchange ideas, work in a team, and solve problems in a multicultural environment. This approach is critically important for interactive learning and prepares competitive specialists who quickly adapt to changes in the global labor market.

During the study of distance and blended learning, students in the experimental group raised the question of ensuring the quality of effective interactive learning for participants in the educational process. It is easy to conduct an oral survey or organize a conversation in an online conference; however, to ensure group work, joint creative work, games, and competitions, the teacher had to master modern digital tools and prepare special didactic support. For this, the teachers used interactive electronic didactic materials developed for these purposes, created them using various software and online services. Interactive tools for implementing interactive learning have become an integral part of the EG's work in blended and distance learning.

Organization and results of the ascertaining stage of the experimental study.

Analysis of the results of the formation of the motivational component of students' interactive educational interaction showed the following: low level – 48.0%; average level – 32.1%; high level – 19.9%. The results indicate the advantage of the low level.

Analysis of the results of the formation of the epistemological component of students' interactive educational interaction showed the following: low level – 50.0%; average level – 31.7%; high level – 18.3%. Analysis of the results of epistemological component formation indicates a low level of interactive educational interaction.

Analysis of the results of the formation of the praxeological component of students' interactive educational interaction showed the following: low level – 64.1%; average level – 26.7%; high level – 9.2%.

Analysis of the results of the formation of the praxeological component indicates a low level of formation of interactive educational interaction.

Thus, the ascertaining stage of the scientific research established a low level of formation of interactive educational interaction and its strengthening; a low level of preparedness of specialists as an indicator of work capacity; and an insufficient level of knowledge about the phenomenon under study and skills in using interactive educational interaction and digital innovative technologies.

EG students were engaged in the formative stage of the research according to the proposed author's system and pedagogical conditions of interactive educational interaction, and CG students according to the usual methodology.

Formative stage of experimental research.

The formative stage of the experiment was carried out in accordance with the author's developed system and the defined pedagogical conditions for interactive educational interaction in higher education, as described above in the article.

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We formed an experimental (EG) and a control (CG) group during the formative experiment. For the experiment, the selection of groups was carried out to ensure homogeneity and representativeness. It was established that when studying interactive educational problems, the minimum number of participants in the experimental and control groups should be 60. To determine the effectiveness of the proposed author's system and the pedagogical conditions of interactive educational interaction in the CG (84 respondents) and EG (86 respondents) at the beginning and end of the formative stage of the experiment. Throughout the entire period of the pedagogical experiment (formative stage). The composition of the CG and EG groups remained unchanged.

The initial level of formation (confirmatory section) of all components of the studied phenomenon and the number of people before the beginning of the experiment were statistically the same, that is, close in value, indicating the same conditions for the start of the experimental study for students of the CG and EG. We will show this in the tables.

Table 4.
The state of formation of the motivational component of interactive educational interaction of students before the beginning of the formative stage of the pedagogical experiment (confirmatory stage) (%)

Group	Motivational component		
	High Level	Average Level	Low Level
Experimental Group	19,9 %	32,1 %	48,0%
Control Group	19,9%	32,0%	48,1%

Table 5.
State of formation of the epistemological component of interactive educational interaction of students before the beginning of the formative stage of the pedagogical experiment (confirmatory stage) (%)

Group	Epistemological component		
	High Level	Average Level	Low Level
Experimental Group	18,3 %	31,7%	50,0%
Control Group	18,3%	31,6%	50,1%

Table 6.
State of formation of the praxeological component of interactive educational interaction of students before the beginning of the formative stage of the pedagogical experiment (confirmatory stage) (%)

Group	Praxeological component		
	High Level	Average Level	Low Level
Experimental Group	9,2 %	26,7%	64,1%
Control Group	9,0%	26,8%	64,2%

Analysis of the tables indicates a low level of student interaction before the beginning of the formative stage of the pedagogical experiment across all components. Thus, students in the CG and EG groups began participation in the experimental study with almost identical indicators.

The determination of the reliability of differences and similarities in the study was established by the difference or identity of the characteristics of the EG and CG, which made it possible to formulate statistical hypotheses:

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- Null hypothesis H_0: the distribution of indicators of the levels of formation of interactive educational interaction of students of the EG does not differ from the indicators of the formation of the phenomenon under study of the CG; therefore, they belong to the same general population.
- Alternative hypothesis H_1: the distributions of indicators of the levels of formation of interactive educational interaction among students of the EG differ from those of the CG; therefore, they do not belong to the same general population.
- We calculated the Pearson χ^2 test to test the statistical hypothesis for comparing two independent samples. It was necessary to know the dependence between the two variables from the results' frequency distribution to apply it, which allows investigating whether they are related or independent. Thus, this statistical method is used to process qualitative data and is calculated by the formula:

$$\chi^2_{emp} = \frac{1}{n_{EG} \times n_{CG}} \times \sum_{i=1}^{3} \frac{(n_{EG} \times Q_{CGi} - n_{CG} \times Q_{EGi})^2}{Q_{EGi} + Q_{CGi}}$$

n_{EG} shows the number of respondents in the experimental group;
n_{CG} shows the number of control group respondents;
Q_{CGi} and Q_{EGi} – shows the number of respondents in the control and experimental groups, respectively.

We assessed the reliability of the experimental data using the χ^2 criterion. Experimental data measured on an ordinal scale of u = 3, in particular: u = 1 – "low", u = 2 – "average", u = 3 – "high".

We calculated the χ^2_{emp} criterion using the formula:

$$\chi^2_{emp} = \frac{1}{61 \cdot 62}\left(\frac{(61 \cdot 7 - 62 \cdot 6)^2}{6+7} + \frac{(61 \cdot 21 - 62 \cdot 20)^2}{20+21} + \frac{(61 \cdot 34 - 62 \cdot 35)^2}{35+34}\right) = 0{,}122$$

We found the degree of freedom using the formula:

U= i – 1,
i – number of highlighted levels. U = 3 – 1= 2 − respectively. We find the critical value of the Pearson χ^2 criterion.

The critical value of χ^2 is 5.991 at a significance level of $p < 0.05$. The significance level of p = 0.948. The relationship between the effective and actual features is statistically insignificant. Therefore, the null hypothesis is confirmed: before the beginning of the formative stage of the experimental study, the respondents in the EG and CG groups had the same level of interactive educational interaction, which is statistically the same and differs at the 0.05 significance level.

We conducted a diagnostic evaluation of the effectiveness of the proposed system and the pedagogical conditions of the studied phenomenon after the completion of the formative stage, based on a comparison of results from the experimental and control groups.

Results of the formative stage of the experimental study.

The results of the formative stage of the experiment were systematized, generalized, statistically processed, and implemented in further practice; a comparative analysis of the study was conducted using mathematical statistics methods.

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To verify the effectiveness of the proposed system and the pedagogical conditions, a comparative analysis of the results from the formative and ascertaining stages was conducted against the specified criteria and indicators.

In particular, the generalized results on the formation of the motivational component of interactive educational interaction among students at the formative stage of the experiment are presented in Table 4.

Table 7.
State of formation of the motivational component of interactive educational interaction of students (formative stage) (%)

Group		Motivational component		
		High Level	Average Level	Low Level
EG	Before the experiment	19,9 %	32,1 %	48,0%
	After the experiment	35,7%	41,4%	22,9%
CG	Before the experiment	19,9%	32,0%	48,1%
	After the experiment	21,9%	31,0%	47,1%

Analysis of Table 4 results shows that the EG respondents' indicators of the formation of the motivational component increased at the end of the experiment's formative stage.

Table 8.
State of formation of the epistemological component of interactive educational interaction of students (formative stage) (%)

Group		Epistemological component		
		High Level	Average Level	Low Level
EG	Before the experiment	18,3 %	31,7%	50,0%
	After the experiment	29,9%	48,3%	21,8%
CG	Before the experiment	18,3%	31,6%	50,1%
	After the experiment	19,7%	32,6%	47,7%

Analysis of the results in Table 5 shows that the percentage of EG students with indicators of a average-to-high level of formation of the studied phenomenon has significantly increased. Accordingly, the number of students with a low level of interactive educational engagement has decreased.

Table 9.
State of formation of the praxeological component of interactive educational interaction of students (formative stage) (%)

Group		Praxeological component		
		High Level	Average Level	Low Level
EG	Before the experiment	9,2%	26,7%	64,1%
	After the experiment	37,8%	39,3%	22,9%
CG	Before the experiment	9,0%	26,8%	64,2%
	After the experiment	10,8%	38,1%	51,1%

Analysis of the results in Table 6 shows that the respondents of the EG have a significant increase in the high level of formation of the praxeological component and in the average level. Accordingly, the percentage of respondents with a low level of formation of the praxeological component has significantly decreased. In the EG, the results differ slightly from the ascertaining cut.

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After the experimental study, the value of the Pearson χ^2_{emp} criterion is 15.001. The critical value of χ^2 is 12.592 at a significance level of p=0.05. At the $p < 0.05$ significance level, the relationship between the effective and factor characteristics is statistically significant. This indicates the reliability of the differences in the phenomenon under study's formation between the EG and CG, and it is 95% at the end of the experiment.

The indicators presented in the EG data tables indicate an increase in students' interactive educational engagement, driven by the implementation of the author's developed system and certain pedagogical conditions.

The results of the formative stage demonstrate statistically significant improvements in the level of interactive educational interaction among students of the experimental group compared with the control group. The obtained value of the Pearson chi-square test ($\chi^2_{emp} = 15.001$, $p < 0.05$) confirms that the observed changes cannot be explained by random variation and indicate the effectiveness of the implemented pedagogical system. The most significant positive dynamics were observed in the praxeological component, where the proportion of students with a high level increased from 9.2% to 37.8%, while the share of students with a low level decreased from 64.1% to 22.9%. In contrast, the control group demonstrated only minor improvements, indicating the limited effectiveness of traditional teaching approaches in fostering interactive educational engagement.

The obtained results are consistent with previous studies emphasizing the effectiveness of interactive learning environments in higher education. In particular, Gallach et al. (2020) report that the use of interactive classroom methods contributes to the development of analytical thinking, autonomous learning, and higher academic achievement among students. Similarly, Armson et al. (2020) demonstrate that collaborative learning formats significantly increase student engagement and improve the practical application of knowledge compared to traditional lecture-based instruction. The findings of the present research support these conclusions and further confirm that interactive learning strategies can substantially improve the professional training of future specialists.

At the same time, the results of this study extend the conclusions of previous research by demonstrating the effectiveness of a systematic pedagogical model that integrates multiple digital interactive tools. While earlier studies often focused on the use of individual technologies (e.g., virtual laboratories or online platforms), the present research combines various digital interaction tools, including simulations, webquests, cloud services, and artificial intelligence tools. Such integration creates a multidimensional learning environment that simultaneously stimulates motivation, knowledge acquisition, and the development of practical skills.

The observed differences between the experimental and control groups can be explained by several pedagogical factors. First, the experimental group was exposed to interactive learning scenarios that required active participation, collaboration, and problem-solving. This aligns with the findings of Huai et al. (2024), who emphasize that immersive digital environments promote creative thinking and deeper cognitive engagement. Second, the use of collaborative digital tools allowed students to participate in group problem-solving and joint project activities, which strengthened interpersonal interaction and collective knowledge construction.

Another important factor influencing the observed improvements is the integration of artificial intelligence and digital analytical tools into the learning process. As noted by Nussbaum & Bekerman (2025), AI technologies support analytical reasoning,

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information processing, and research-oriented learning activities. In the present study, the use of such technologies enabled students to analyze information more efficiently, visualize research results, and participate more actively in scientific inquiry.

The improvement in the motivational component of interactive educational interaction can also be explained by the transformation of the teacher's role within the interactive learning environment. Instead of acting solely as a transmitter of information, the teacher in the experimental group functioned as a facilitator, consultant, and coordinator of collaborative learning activities. This pedagogical shift created conditions for greater student autonomy and responsibility for learning outcomes, which significantly increased motivation and engagement in the educational process.

In contrast, the control group continued to study according to traditional instructional methods, which are typically characterized by limited student interaction and a predominance of passive learning formats. As a result, students had fewer opportunities to develop collaborative learning skills, which explains the relatively minor changes observed in the control group's indicators.

The results of the study demonstrate a clear causal relationship between the implemented pedagogical intervention and the observed improvements in students' interactive educational engagement. The author's pedagogical system created a structured digital learning environment that stimulated motivation, supported knowledge acquisition, and facilitated the development of practical collaborative skills. Consequently, the integration of interactive digital technologies and well-defined pedagogical conditions significantly enhanced the professional preparation of future specialists.

The obtained results confirm the effectiveness of the proposed pedagogical system aimed at organizing interactive educational interaction in higher education. At the same time, a deeper analysis of the results allows us to identify several important pedagogical implications and limitations that should be taken into account when interpreting the findings.

First, the positive dynamics observed in the experimental group across all three components – motivational, epistemological, and praxeological – indicate that interactive learning environments supported by digital technologies significantly enhance students' engagement in the educational process. The most pronounced improvement was observed in the praxeological component, which reflects the development of practical skills required for collaborative learning and the application of digital educational tools. This result suggests that interactive learning is particularly effective in developing applied competencies that are directly relevant to students' future professional activities.

However, the moderate effect sizes identified in the statistical analysis (Cohen's d ranging from 0.41 to 0.55) indicate that although the pedagogical intervention produced meaningful improvements, its impact should not be interpreted as universally transformative. Interactive technologies alone do not automatically guarantee high levels of student engagement or competence development. Their effectiveness largely depends on the pedagogical design of learning activities, the level of teacher preparedness, and the degree of students' readiness for active participation in collaborative learning environments.

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Another important aspect revealed by the study is the interdependence between motivational, epistemological, and praxeological components of interactive educational interaction. The correlation analysis demonstrates that theoretical understanding of interactive learning principles is closely connected with students' ability to apply these principles in practice. This finding highlights the importance of integrating conceptual knowledge with experiential learning activities. In other words, effective interactive learning requires not only access to digital technologies but also structured pedagogical strategies that guide students in applying theoretical knowledge to practical tasks.

From a pedagogical perspective, the results also emphasize the importance of transforming the traditional role of the teacher. In interactive learning environments, teachers function not only as knowledge transmitters but also as facilitators, mentors, and coordinators of collaborative learning activities. Such a transformation requires the development of new pedagogical competencies among university teachers, including the ability to design interactive digital learning environments and manage collaborative learning processes.

At the same time, the study reveals several challenges associated with the implementation of interactive technologies in higher education. One of the key challenges is the need for systematic professional development of teachers. Without adequate methodological training and institutional support, the integration of digital interactive technologies may remain superficial and fail to produce sustainable improvements in educational outcomes.

Another important issue concerns the scalability of the proposed pedagogical system. The experiment was conducted within a limited educational context involving several Ukrainian higher education institutions. Consequently, the results may be influenced by institutional conditions, technological infrastructure, and the digital competencies of both teachers and students. Therefore, further research is needed to examine the applicability of the proposed model in different educational contexts and disciplines.

In addition, although the study demonstrates short-term improvements in students' interactive educational engagement, it does not provide evidence regarding the long-term impact of such pedagogical interventions on students' professional competence development or their performance in real professional environments. Longitudinal studies would be valuable for examining whether the observed improvements persist over time and contribute to graduates' professional success.

Despite these limitations, the findings of the study provide important insights into the pedagogical potential of interactive learning environments supported by digital technologies. The results suggest that the systematic integration of interactive digital tools with clearly defined pedagogical conditions can significantly improve the quality of professional training in higher education. Moreover, such environments promote the development of competencies that are increasingly important in modern knowledge-based societies, including collaboration, critical thinking, problem-solving, and digital literacy.

Thus, the expanded interpretation of the results confirms that interactive learning should be considered not merely as a technological innovation but as a comprehensive pedagogical strategy that requires the alignment of technological, methodological, and organizational components within the educational process.

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Conclusions

The study investigated the role of interactive learning as a factor in the professional development of higher education students in the context of digital transformation of education. The research aimed to develop and empirically verify the effectiveness of an authorial pedagogical system and pedagogical conditions for organizing interactive educational interaction in the training of future specialists. The results of the pedagogical experiment confirmed the effectiveness of the proposed approach and demonstrated statistically significant improvements in the levels of interactive educational interaction among students of the experimental group.

The implementation of the author's system, which integrated interactive digital tools such as virtual laboratories, simulations, artificial intelligence applications, online collaborative platforms, and webquests, contributed to a substantial increase in students' motivational, epistemological, and praxeological components of interactive learning. The most significant changes were observed in the development of practical interactive skills and collaborative learning abilities. Statistical verification using the Pearson chi-square test confirmed the reliability of the obtained results and demonstrated significant differences between the experimental and control groups after the formative stage of the experiment.

The findings of the study confirm the importance of integrating interactive digital technologies with well-defined pedagogical conditions in higher education. The research shows that interactive educational environments stimulate students' motivation for learning, support deeper knowledge acquisition, and promote the development of practical competencies necessary for professional activity in a digital society. In this regard, the proposed pedagogical system contributes to improving the quality of professional training of future specialists and can serve as a methodological basis for designing interactive learning environments in higher education institutions.

The practical significance of the research lies in the possibility of applying the developed pedagogical system and methodological recommendations in the organization of interactive learning in universities. The results may be useful for teachers, educational administrators, and curriculum developers seeking to modernize the educational process and enhance students' professional competencies through digital and interactive learning tools.

At the same time, the study has several limitations. The experiment was conducted within a limited sample of students from Ukrainian higher education institutions, which may influence the generalizability of the findings to other educational contexts. In addition, the research primarily focused on pedagogical and technological aspects of interactive learning without analyzing long-term effects on students' professional performance after graduation.

Future research may focus on expanding the sample of participants, conducting cross-institutional and international comparative studies, and exploring the long-term impact of interactive educational environments on professional competence development. Further investigations may also examine the potential of emerging technologies, including artificial intelligence, immersive virtual environments, and adaptive learning systems, for enhancing interactive learning in higher education.

Overall, the results of the study confirm that the systematic integration of interactive technologies and pedagogically grounded instructional strategies significantly

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improves the effectiveness of professional training in higher education and supports the development of competencies required for successful participation in modern digital professional environments.

The main scientific contribution of this study is the development and empirical validation of a structured pedagogical system that integrates interactive digital technologies with clearly defined pedagogical conditions for organizing interactive educational interaction in higher education.

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Original Article

Chatbots and virtual assistants in higher education: supporting academic writing and research

Chatbots y asistentes virtuales en la educación superior: apoyo a la escritura y la investigación académica

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Abstract

The article aimed to analyze the impact of chatbot-assisted support on the development of academic writing and research competencies of higher education students. The proposed study was implemented using a quasi-experimental mixed design with control and experimental groups (n = 180) and measurements before and after the intervention. The assessment was carried out using the analytical rubric of academic writing, the research competencies index, as well as through AI literacy questionnaires and qualitative analysis of student reflections. The results showed a significant and moderate positive impact of the intervention. In particular, the quality of academic writing, its organization, sentence construction, and logic of argumentation improved. An increase in research competencies was also found in the experimental group of students. Besides, correlation and regression analyses showed that the level of AI literacy is a more important predictor of academic outcomes than the frequency of use of the digital assistant. The conclusion states that chatbots and virtual assistants effectively performed the function of cognitive and methodological support for academic writing and research under conditions of clear pedagogical integration and adherence to the principles of academic integrity.

Keywords: academic writing, chatbots, higher education, research competencies, virtual assistants.

Resumen

El objetivo del artículo fue analizar el impacto del apoyo asistido por chatbots en el desarrollo de la escritura académica y las competencias de investigación de estudiantes de educación superior. El estudio propuesto se implementó mediante un diseño mixto cuasiexperimental con grupos control y experimental (n = 180) y mediciones antes y después de la intervención. La evaluación se realizó mediante la rúbrica analítica de escritura académica, el índice de competencias de investigación, así como mediante cuestionarios de alfabetización en IA y análisis cualitativo de las reflexiones de los estudiantes. Los resultados destacaron un impacto positivo estadísticamente significativo y moderado de la intervención en la calidad de la escritura académica, su organización estructural y la lógica de la argumentación. También se observó un aumento en las competencias de investigación en el grupo experimental de estudiantes. Los análisis de correlación y regresión mostraron que el nivel de alfabetización en IA es un predictor más importante de los resultados académicos. La conclusión afirma que los chatbots y los asistentes virtuales desempeñaron eficazmente la función de apoyo cognitivo y metodológico para la escritura

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académica y la investigación en condiciones de clara integración pedagógica y adhesión a los principios de integridad académica.

Palabras clave: asistentes virtuales, chatbots, escritura académica, competencias de investigación, educación superior.

Introduction

The digital transformation of higher education in recent years has turned into a new dimension of the educational sector, characterized by the active introduction of artificial intelligence (AI) into educational and scientific practices. A special place among such technologies has been occupied by chatbots and virtual assistants, which have been increasingly used as information support tools and in the field of application of cognitive, methodological and research support for the academic activities of teachers and students. In the context of the permanent increase in requirements for the quality of academic writing, scientific integrity and research productivity, the issue of the role of such digital tools in higher education has gained additional relevance.

Academic writing and research activities have traditionally been considered one of the most complex components of university training (Ebrahim et al., 2025). They required already formed thorough subject knowledge, which had to be combined with the formation of skills in argumentation, text structuring, critical analysis of sources, adherence to stylistic and ethical standards of scientific communication. For the majority of students – especially in the context of a multilingual academic environment and the internationalization of education – such requirements have become a rather serious barrier that has affected the further success of their studies and the involvement of students in research work.

In this context, chatbots and virtual assistants have emerged as potential tools for further support for students, capable of performing the functions of individualized mentoring, promptly responding to feedback calls, and working as navigators in the academic environment (Cabeza-Rodríguez, 2025; Imran & Almusharraf, 2023). They could contribute to research planning, clarifying scientific issues, improving the structure of academic texts, language editing, and identifying methodological aspects. At the same time, their use has given rise to a number of theoretical and practical issues that researchers have addressed. First of all, these problems were related to the limits of automated assistance, the transformation of authorship, the risks of superficial knowledge acquisition, and further challenges to maintaining academic integrity.

Despite the increase in the number of scientific publications devoted to the use of AI in education, there have been few studies that systematically analyze the role of chatbots and virtual assistants specifically in the field of academic writing and scientific research in higher education (Jardón Gallegos et al., 2024; María Jimenez et al., 2024). Many available scientific works have focused on the technical characteristics of the tools and the general pedagogical effects of their use (Rivadeneira et al., 2024; Usher & Amzalag, 2025). At the same time, the analysis of their impact on cognitive processes, the importance of academic culture, and the research autonomy of students is insufficiently conducted in the modern scientific space.

The purpose of the proposed article will be to consider chatbots and virtual assistants as tools for supporting academic writing and scientific research in higher education. The study aimed to identify the main areas of their application, potential

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benefits, and limitations. Another important issue was to clarify the educational and ethical challenges that accompany the integration of these technologies into the academic environment. Therefore, the article aimed to contribute to the current discussion on the role of artificial intelligence in the transformation of university education and research.

Literature Review

Since 2021, the scientific literature has seen a significant increase in interest in the use of chatbots and virtual assistants in higher education. This state of affairs is due to the development of generative AI and its comprehensive integration into educational platforms. Studies devoted to this issue have covered a wide range of challenges (Böhmer, 2023; Campbell & Cox, 2024) – from pedagogical effectiveness and user acceptance of technologies to ethical, methodological and cultural challenges that have been associated with the transformation of academic writing and research.

Main research vectors

The first body of research focused on the perception and acceptance of chatbots and virtual assistants by students and teachers. In the works carried out in Spain and Latin American countries, the authors applied quantitative methods (surveys, structural models based on UTAUT or TAM), which allowed them to identify key factors of use: expected benefits, ease of use, institutional support and regulatory certainty (Cabero-Almenara et al., 2025; Villegas-Ch et al., 2021). The results showed that higher education students primarily perceived chatbots as an auxiliary tool for organizing learning and writing assignments, while teachers had a more cautious attitude, which was associated with the risks of academic dishonesty and reduced autonomy of learning.

The second direction covered the study of the impact of chatbots on academic writing (Abbas et al., 2022; Bond et al., 2025). A significant part of the Spanish-language works from the regions of Spain, Mexico, Peru and Ecuador analyzed the use of chatbots for language correction, text structuring, idea generation and feedback (Anjulo Lambebo & Chen, 2024). Methodologically, these studies were based on student surveys, analysis of academic texts before and after the use of AI tools, as well as qualitative interviews. Such results indicated a positive effect in the short term (reduction of anxiety, increased confidence in writing, improved formal quality of texts) (Guillén-Yparrea & Hernández-Rodríguez, 2024), while also recording a limited impact on the development of deeper argumentation and critical thinking skills.

The third block of studies is devoted to supporting research activities in higher education (García Sánchez, 2023). In these works, chatbots and virtual assistants are considered as tools to help formulate research questions, explain methodological approaches, conduct preliminary literature reviews, and organize scientific texts. Studies from Latin America and the Caribbean have shown that such tools were particularly in demand by master's degree students and early-stage researchers who faced a shortage of individual scientific support (Lucero Fredes et al., 2022; Salas-Pilco & Yang, 2022).

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Key findings

The literature review showed the dominance of descriptive and correlational studies. At the same time, experimental and longitudinal studies were rare. In the regions of Spain and Latin America, interdisciplinary teams that combined pedagogy, educational technology, and applied linguistics prevailed (Ortiz-Bonnin & Blahopoulou, 2025; Peña Cáceres et al., 2025). Most authors agreed that chatbots are effective as support tools, but they cannot replace full-fledged training in academic writing or research methods (Sánchez-Ticona et al., 2023).

At the same time, a significant part of the work emphasized the contextual dependence of the results. The effectiveness of the use of chatbots varied depending on the linguistic environment, digital literacy of students, institutional policies, and cultural perceptions of authorship and learning (Tarchi et al., 2024; Tobin, 2024). This is especially noticeable in Central American and Caribbean countries, where access to digital resources and the regulatory framework were often uneven.

Thus, the current literature has a number of limitations. First, most studies have focused on the general use of chatbots. Accordingly, researchers often did not distinguish functionally between chatbots for service support and virtual assistants for cognitive and research support. Second, there is a lack of work that would indicate the long-term impact of these tools on the formation of academic competencies, in particular the ability to independently write and think scientifically.

Thus, the available scientific literature has demonstrated the potential of chatbots and virtual assistants as tools for supporting academic writing and research in higher education. However, a need was identified for an analysis of the role of virtual assistants in supporting the learning environment. It is these gaps that determined the relevance of further analysis of the role of such technologies.

Methodology

Research Design

The proposed study was conducted using a quasi-experimental mixed-methods design with control and experimental groups and pre-test/post-test measurements.

This design made it possible to effectively assess the impact of chatbots and virtual assistants on teaching academic writing and research skills in the context of the real educational process. Also, while maintaining the validity of the results, control for initial differences between groups was ensured through statistical procedures.

Participants and Sample

A total of 180 higher education applicants participated in the study. The formation of groups was based on existing academic streams (without full randomization), which corresponded to the natural conditions of university education. To minimize the impact of group unevenness in starting characteristics, all participants took an initial pre-test to determine the level of academic writing and self-assessment of research competencies. Participants also completed a short questionnaire on their previous experience with AI tools. All participants provided informed consent to participate in the study. Overall, the proposed quasi-experiment was conducted in compliance with the rules and principles of voluntariness, confidentiality, and academic integrity.

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Conditions and intervention

Participants were divided into two groups.

Participants in the control group were trained in academic writing and basic elements of research work exclusively according to standard educational programs (text planning, argumentation, working with sources, formatting references, avoiding plagiarism, etc.). In contrast, participants in the experimental group had a standard program, which was supplemented by the regulated use of a chatbot/virtual assistant as a tool to support writing and research.

To prevent the appearance of the "free use" effect and ensure the reproducibility of the intervention, structured scenarios for using the tool were introduced in the experimental group, which did not provide for the generation of ready-made fragments of academic text "on a turnkey basis". At the same time, assistance in the form of cognitive and methodological "scaffolding" was allowed. In particular, participants in the experimental group were entitled to the following types of interaction:

clarification and narrowing of the topic, formulation of the problem and research questions;
creation of a plan/logic of sections, recommendations for improving the argumentation;
explanation of methodological terms and choice of research design;
linguistic and stylistic editing of individual sentences/paragraphs without changing the authorship;
creation of self-check checklists (coherence, logical connections, citation style requirements).

The requirements of academic integrity were equally emphasized for both groups. Participants received short "allowed/forbidden" protocols, which were supposed to minimize the risks of opaque authorship and abuse.

Instruments and indicators

Before and after the intervention, participants completed a standardized writing task (essay/short research text) with the same requirements for structure and use of sources. The texts were assessed using an analytical rubric (scales with several subcomponents), which covered the logic of the structure (introduction–argumentation–conclusion), the quality of the argumentation and criticality, the work with sources (relevance, integration, correctness of references), academic style and accuracy of formulations, coherence and readability of the text.

The assessment was carried out by independent experts/reviewers who did not know to which group the author of the text belonged (blind scoring). The consistency of the assessment was checked using interrater reliability indicators.

An analysis of research competence was performed (additional outcome). In particular, the implementation of a short test/exercise on the formulation of the problem, hypotheses and variables was monitored, and self-assessment of research competence (planning, selection of methods, interpretation) was determined.

The levels of technology acceptance and digital readiness (explanatory variables) were assessed. In particular, for the experimental group, the following indicators

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were recorded: benefits and convenience (based on TAM/UTAUT logic), AI/digital literacy (basic understanding of limitations and risks), frequency and features of the use of individual types of tool use (short journal/self-report after tasks).

To understand how exactly the chatbot/assistant influenced writing and research thinking, open-ended responses from participants were collected regarding the usage strategy, targeted short interviews/focus groups with a subsample, examples of “before/after text” (portfolio) for content analysis of changes.

Procedure

At the beginning of the study, a Pre-test was carried out: written task + measurement of research competences + experience/readiness questionnaire. The assessment, as already noted, was carried out as a result of the involvement of external experts/reviewers.

Actually, the educational intervention lasted 3-4 months. During this time, control measures (4 written and research mini-tasks) were carried out within each course.

The experimental group used a digital assistant and AI in accordance with the regulations.

Post-test consisted of a repeated written task and repeated measurements, collecting qualitative data.

Data analysis

To check the differences between the groups after the intervention, ANCOVA was used, where the post-test was the dependent variable, the group was a factor, and the pre-test was a covariate. This made it possible to correctly control the starting differences without full randomization. Effect sizes (for example, Cohen’s d or partial η^2) were calculated separately. For additional analysis, regression models were used that assessed the contribution of AI literacy, previous experience, and technology adoption indicators to the increase in results. The reliability of the scales was tested using Cronbach’s α, and the assumptions of the models were tested using standard diagnostic procedures.

A qualitative analysis method was used for open-ended responses. Such materials and interviews were analyzed using thematic analysis. In particular, the qualitative component was used as an explanatory sequential component to interpret quantitative effects: which practices of using the assistant contributed to progress, and which led to superficial changes or dependence.

Ethical and quality guarantees

The study was implemented in compliance with the principles of informed consent, data anonymization, and voluntary participation. To minimize the risks of academic dishonesty, the intervention was designed to support the process rather than replace authorship: participants received the rules of acceptable use, and the evaluation focused on the quality of argumentation, work with sources, and the logic of the study.

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Results and Discussion

Results

Before the intervention began, it was necessary to determine how much the performance of the control and experimental groups differed in terms of academic writing and research skills. Initial measurements showed that both groups were at approximately the same starting level. In particular, the differences identified were not statistically significant. In particular, the mean values of academic writing scores were 63.4 (SD = 8.9) in the control group and 64.1 (SD = 9.1) in the experimental group. The level of research competence was 3.21 (SD = 0.54) in the control group and 3.24 (SD = 0.57) in the experimental group. (See Table 1). This made it possible to consider further changes as being related to the learning conditions, rather than to the previous inequality of the participants.

Table 1.
Descriptive statistics of pre-test measures

Measure	Group	N	Mean	SD
Academic writing score (pre)	Control	90	63.4	8.9
	Experimental	90	64.1	9.1
Research competence (pre)	Control	90	3.21	0.54
	Experimental	90	3.24	0.57

During the intervention period, both groups improved their scores. However, the nature of this increase differed. In the control group, progress was more moderate and uniform. This state of affairs was fully consistent with typical dynamic indicators of the development of academic writing skills. In contrast, in the experimental group, the increase in scores was noted as more significant. This increase was concentrated mainly in those aspects of writing that were related to the structure of the text and the logic of argumentation.

At the same time, to assess the effect of the intervention, an ANCOVA was used, in which the results of academic writing after testing were the dependent variable, the type of group was the independent variable, and the pre-test was the covariate. Hence, the data indicated a significant effect of group type ($F = 18.72$; $p < .001$; Partial $\eta^2 = .096$). This indicated a medium effect of the intervention. The effect of pretest as a covariate was also significant ($F = 41.55$; $p < .001$; Partial $\eta^2 = .191$).

Table 2.
ANCOVA results for academic writing performance

Source	F	p	Partial η^2
Group (control vs experimental)	18.72	< .001	.096
Pre-test (covariate)	41.55	< .001	.191

After the intervention, students in the experimental group who worked with a chatbot or a virtual assistant in a regulated format had higher scores in academic writing, even taking into account their initial level. This demonstrated the importance of using digital assistants to support the learning process and enhance its educational effectiveness.

The qualitative nature of this impact was also determined on the basis that students in the experimental group structured their texts better, formulated the main theses more clearly, and built their arguments more consistently. In their works, logical

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"gaps" between parts of the text were smoothed out, and introductions and conclusions demonstrated a higher level of coherence with the main content. Under such circumstances, the digital assistant performed the function of a kind of cognitive "navigator" that helped students maintain the general logic of the written assignment at a higher level.

On the other hand, the results show that linguistic and stylistic aspects (e.g. formal academic language or precision of formulations) improved less dynamically. This allowed us to demonstrate that chatbots and virtual assistants are more effective as tools for organizing thinking and structure. At the same time, their effectiveness as tools for the deep development of stylistic skills is less noticeable. Therefore, additional analysis of the subcomponents of writing demonstrated that more substantial differences between groups were observed in text structure, logic of argumentation, and coherence. At the same time, linguistic and stylistic aspects showed more moderate growth (See Table 3).

Table 3.
Post-test differences by writing components

Component	Control (M ± SD)	Experimental (M ± SD)	t	p
Text structure	3.42 ± 0.61	3.91 ± 0.58	5.01	< .001
Argumentation	3.35 ± 0.64	3.82 ± 0.60	4.36	< .001
Use of sources	3.18 ± 0.66	3.47 ± 0.63	2.84	.005
Academic style	3.51 ± 0.59	3.68 ± 0.57	1.96	.052

Post-test analysis of research competencies also confirmed a statistically significant effect of the intervention. Students in the experimental group demonstrated a better ability to formulate research questions and research logic. The effect size (Cohen's d = 0.69) indicated a medium practical impact of the intervention on the development of students' research competence. (See Table 4).

Table 4.
Group differences in research competence (post-test)

Measure	Control (M ± SD)	Experimental (M ± SD)	Cohen's d
Research competence index	3.38 ± 0.49	3.71 ± 0.46	0.69

To compare the post-experimental academic writing profiles in the control and experimental groups, Figure 3 presents a radar chart of key components of writing (See Figure 1).

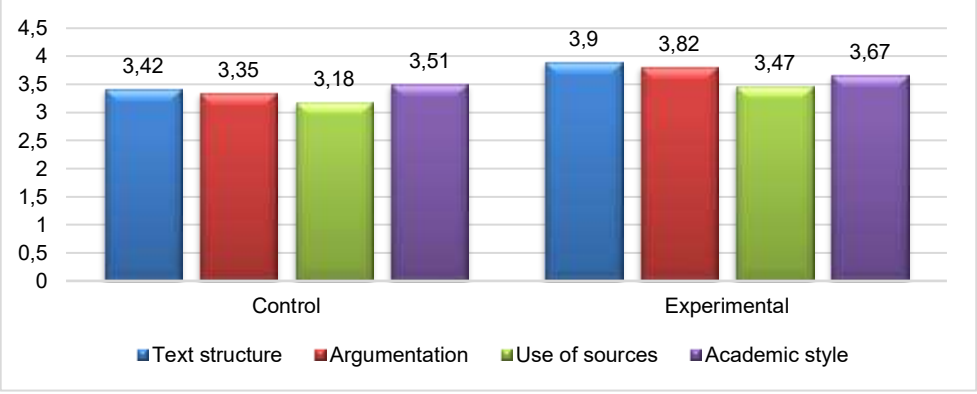


Figure 1. Chart of writing components (control vs experimental, max 5 points).

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Correlation analysis provided an understanding of the mechanisms behind the observed effects. It was found that academic writing performance was moderately correlated with research competency. As a result, there was an interdependence between these competencies. In other words, students who had a better understanding of the logic of the research task tended to complete the written task in a more structured and convincing manner. The relationship between writing performance and AI literacy was particularly striking. In particular, students who had a higher level of awareness of the possibilities and limitations of AI benefited significantly more from using this digital assistant. In contrast, the frequency of chatbot use was less strongly associated with academic performance. Correlation analyses were conducted to identify the main relationships between the intensity and nature of assistant use, digital readiness, and learning outcomes (see Table 5).

Table 5.
Pearson correlations among key variables (experimental group)

Variable	1	2	3	4
1. Academic writing gain	—			
2. Research competence gain	.48**	—		
3. AI literacy	.41**	.36**	—	
4. Frequency of chatbot use	.29*	.22*	.34**	—

* $p < .05$, ** $p < .01$

The results indicated that academic writing performance was correlated with AI literacy and research competencies. The regression model further confirmed these observations. It was demonstrated that AI literacy and basic research competency were important predictors of improved writing performance ($\beta = 0.32$, $t = 4.21$, $p < 0.001$). The frequency of use of a digital assistant had a positive direction of influence ($\beta = 0.27$, $t = 3.58$, $p = 0.001$). Frequency of chatbot use showed a positive, but insignificant, effect ($\beta = 0.14$, $t = 1.97$, $p = 0.051$).This made it possible to identify the chatbot as not a universal "performance enhancer" (see Table 6).

Table 6.
Multiple regression predicting academic writing gain

Predictor	β	t	p
AI literacy	.32	4.21	< .001
Research competence (pre)	.27	3.58	.001
Frequency of chatbot use	.14	1.97	.051
$R^2 = .38$			

Qualitative analysis of students' reflections and text examples provided a way to complement the quantitative results. Participants in the experimental group most often described the assistant as a tool that helps them "see the structure," "not get lost in the arguments," and "understand where to start." At the same time, some students noted the risk of over-reliance on prompts, which could eventually lead to stereotyped thinking. Such reservations are consistent with the quantitative data, which demonstrated a limited impact of the intervention on the depth of argumentation (See Table 7).

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Table 7.
Analysis of reflections of students in the experimental group

Topic Category	Topic Description	Representative student statements	Analytical interpretation
Support	Assistant helps organize thoughts and build the logic of the text	"It becomes clear where to start." "Provides valuable ideas" "Provides valuable suggestions"	The tool performs the function of cognitive "scaffolding".
Navigating the Argument	Support in maintaining logical sequence	"I no longer get lost in arguments." "I understand where to start." "Provides good guidance." "Structures all important topics."	Reducing cognitive overload and increasing the logical coherence of statements
Overcoming Initial Difficulties	Reducing the fear of the "blank page"	"Now I understand how to start." "Provides good guidance."	Reducing anxiety at the stage of writing initiation
Risk of Addiction	Awareness of the possibility of over-reliance on prompts	"Sometimes I just want to take a ready-made idea." "You can get used to the prompts." "I get used to the prompts, and I feel so comfortable."	Potential threat of forming stereotyped thinking

Discussion

The results confirmed the importance of using chatbots and virtual assistants as support tools. However, these digital mechanisms are not intended to completely replace subjects such as academic writing and research in higher education. The quasi-experimental design made it possible to record a moderate and stable positive effect of the intervention, which was primarily reflected in the improvement of the structural organization of texts, the logic of argumentation and related research competencies. This nature of the results is fully consistent with modern studies, which emphasize that the greatest potential of generative AI lies in the functions of cognitive "scaffolding" (Bohomaz et al., 2023; Krumsvik, 2024), and not in forming a direct line of academic content generation.

An important observation in the proposed results was that the most pronounced effects were recorded precisely in the higher cognitive components of writing. In contrast, linguistic and stylistic aspects showed only a moderate increase. This confirmed the findings of other researchers that chatbot-assisted support had a positive impact on the organization of thinking, text planning, and understanding the logic of argumentation. However, this did not replace the process of long-term formation of an academic style, which was also indicated by many researchers. This result was also correlated with the approaches to academic literacy (Peralta & Pila, 2025; Thottoli et al., 2024; Palacios-Núñez et al., 2025), according to which writing was considered as a language skill and at the same time as a form of participation in disciplinary knowledge and research culture.

Particular attention was focused on identifying the role of AI literacy as one of the key factors in the effectiveness of the intervention. Correlation and regression analyses demonstrated how higher education students with a higher level of awareness of the possibilities and limitations of AI benefited more from the use of digital assistants. This made it possible to interpret chatbots both as a universal

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means of improving outcomes and an influential tool, the effectiveness of which depended largely on the user's reflexive and responsible interaction with technology. In this context, the results confirmed existing views on the need to integrate AI literacy elements into academic writing and research skills development programs (Sanz-Tejeda et al., 2026; Urzúa et al., 2025).

At the same time, the relatively weak relationship between the frequency of assistant use and educational outcomes highlighted the limitations of the instrumental approach to the use of AI. Simply increasing the number of calls to the chatbot did not guarantee qualitative changes in writing or research thinking. Instead, the focus on analyzing, testing, and refining one's own ideas became decisive (Getenet & Tualaulelei, 2023). This observation is likely to have important pedagogical implications (McSharry, 2023; Ojeda Carpio, 2025), as it confirmed a shift in focus from controlling the use of technologies to forming a culture of their conscious use.

The qualitative data presented allowed us to further confirm previous scientific findings that students perceived the chatbot primarily as a means of support in the initial stages of writing and research. At the same time, a caveat was noted regarding the risk of stereotyped thinking and superficial acceptance of the proposed formulations. These observations are consistent with quantitative findings that showed limited impact of the intervention on depth of argumentation (Moreno-Guerrero et al., 2022; Khryk et al., 2021). The proposed results highlight the need for pedagogical support for the use of such tools (Labadze et al., 2023).

Overall, the study results add to the existing literature, offering an empirically informed perspective on the role of chatbots and virtual assistants in the development of academic writing and research skills. More broadly, the proposed results demonstrate a transformation of the role of digital tools in higher education, from automation tools to partners in the process of educational thinking (Essel et al., 2022; Polyezhayev et al., 2024). However, the study has methodological limitations. First, the use of a quasi-experimental design without complete randomization limited the ability to broadly generalize causal conclusions. Second, the duration of the intervention was relatively short. Thus, this duration did not allow for the assessment of the long-term impact of chatbot support.

Conclusions

The article analyzes the possibilities of using chatbots and virtual assistants as tools to support academic writing and research activities in higher education institutions. The results of a quasi-experimental study demonstrated that the regulated and pedagogically directed use of such tools had a positive impact on the quality of academic writing (primarily on the structural organization of texts, the logic of argumentation, and related research competencies).

The study also indicated that the effect of support using chatbots was different. In particular, the most pronounced changes were observed in the components that reflected higher cognitive processes. However, linguistic and stylistic characteristics had more moderate changes. This confirmed the feasibility of considering chatbots and virtual assistants as means of cognitive and methodological support. The conscious use of artificial intelligence technologies had a more important impact on learning than the frequency of their use. This indicated the importance of integrating digital and artificial intelligence elements into educational programs.

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The results had practical significance for teachers and educational program developers, as they demonstrated the possibilities of combining traditional learning with artificial intelligence tools under conditions of clear pedagogical regulation and adherence to the principles of academic integrity.

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Original Article

Redefinición de la investigación y el aprendizaje universitario mediante la incorporación de la inteligencia artificial generativa

Redefining university research and learning through the incorporation of generative artificial intelligence

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Resumen

Este artículo de investigación tuvo como objetivo indagar los significados en la trama de las experiencias surgidas en el intercambio con herramientas de inteligencia artificial generativa como ChatGPT, Gemini y Copilot, con el propósito de comprender cómo dichas interacciones contribuyen a la redefinición de los procesos de investigación y aprendizaje en la vida universitaria. El estudio se desarrolló desde la fenomenología hermenéutica en seguimiento del método heideggeriano constituido por un momento fenomenológico y la organización de los argumentos de cada informante. La reconstrucción interpretativa dio lugar a los hallazgos representados en dos macrocategorias: redefinición o nueva lectura de la investigación y el aprendizaje y desafíos éticos de autoría asociados al uso de la IA. Se concluye con una propuesta de redefinición de la investigación y del aprendizaje universitario que constituye un aporte teórico conceptual y se consolida como una contribución metodológica para comprender la dinámica epistémica en la producción de saberes con IA.

Palabras clave: Aprendizaje, redefinición, Inteligencia Artificial, investigación, prompt.

Abstract

This research article aimed to explore the meanings embedded in the experiences arising from interactions with generative artificial intelligence tools such as ChatGPT, Gemini, and Copilot, to understand how these interactions contribute to redefining research and learning processes in university life. The study was developed from a hermeneutic phenomenological perspective, following the Heideggerian method, which consists of a phenomenological phase and the organization of each participant's arguments. The interpretive reconstruction yielded findings represented in two macro-categories: redefinition or new reading of research and learning, and ethical challenges of authorship associated with the use of AI. The article concludes with a proposal for redefining university research and learning, which constitutes a theoretical and conceptual contribution and is consolidated as a methodological contribution to understanding the epistemic dynamics in knowledge production with AI.

Keywords: Learning, redefining, Artificial Intelligence, research, prompt.

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Introducción

Lázaro Pulido & De-Juanas (2024) plantean que la sociedad actual se caracteriza por haber pasado de la era analógica a la era digital. En este sentido, la investigación y el aprendizaje previos a la aparición de las computadoras se sustentaban en el modelo analógico de gestión del conocimiento, en el cual el acceso a la información sucedía en físico consultando repositorios bibliográficos, revistas científicas especializadas; a las cuales se suscribían las universidades y particulares; así como hemerografía disponible en amplios establecimientos dedicados a custodiar la crónica del saber y la historia. El procesamiento de los datos de interés se realizaba utilizando la escritura manual y las máquinas de escribir, donde se ponía en tinta sobre papel el resultado de procesar múltiples informaciones provenientes del análisis, síntesis, evaluación y reinvención crítica y creativa de los datos de interés por parte de un humano. A la fecha, la sociedad analógica se ha vuelto difusa con el paso del tiempo y se observa en la realidad que el mundo impreso ha cambiado, toda vez que, aunque los libros siguen siendo la fuente original de la ciencia preservada, los nuevos entornos digitales resultan de mayor acceso para la búsqueda de información.

La autoría de productos académicos dependía del esfuerzo cognitivo del investigador y del estudiante, quienes podían trabajar de manera individual o colaborativa utilizando laptops y otros recursos tecnológicos para facilitar el desarrollo de sus actividades. Este proceso refleja una evolución histórica de los medios de producción del conocimiento, que va desde los escribas y la imprenta hasta la máquina de escribir y, posteriormente, los equipos portátiles y de escritorio con impresora conectada. En esta línea de análisis, Tapia Peralta et al. (2023) explican en el marco de la transformación en las dinámicas de enseñanza y aprendizaje, el surgimiento de nuevas herramientas y recursos digitales, la personalización del aprendizaje y el fomento de habilidades del siglo XXI, como el pensamiento crítico, la creatividad y la colaboración.

Con la revolución digital, especialmente tras el surgimiento de la web en los años noventa y la consolidación de la era de la información, los procesos de investigación y aprendizaje se desplazaron del conocimiento en formato físico hacia un conocimiento en red, accesible de manera inmediata con un solo clic. Asimismo, la investigación y la consulta pasaron de las bibliotecas físicas a los repositorios digitales y diversos portales en los que es posible acceder a volúmenes inconmensurables de información. De este modo, desde cualquier lugar donde se disponga de un equipo y conectividad, en el último cuarto de siglo los universitarios han podido incorporarse con facilidad a procesos de aprendizaje e investigación. En este sentido, Carrió Pastor (2007) señala que la abundancia de información disponible en Internet ha intensificado la capacidad crítica de los usuarios y ha acelerado los procesos de comprensión y toma de decisiones, transformando los modos en que interpretamos y respondemos al entorno digital.

La llegada de la IAG a las instituciones universitarias en Venezuela sucedió debido a la posibilidad de acceso a la misma por parte de estudiantes y docentes investigadores. En el discurso cotidiano comenzó a abordarse esta nueva tecnología, herramienta o recurso al servicio de la humanidad que podía actuar como un humano con habilidades superlativas para el procesamiento de datos y la producción de información.

Bajo esta consideración de enfoque epistémico, Azevedo Coelho (2026) comprende la Inteligencia Artificial Generativa (IAGen) en la investigación académica, como una infraestructura sociotécnica compleja que afecta criterios de validez

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epistemológica, soberanía cognitiva y autonomía universitaria. La IAG, incluso en sus versiones accesibles y gratuitas, ha simplificado de manera significativa las tareas de búsqueda, análisis y redacción, ofreciendo apoyo inmediato a usuarios con distintas responsabilidades académicas. Su disponibilidad y facilidad de uso han ampliado su presencia en las prácticas cotidianas de docentes, investigadores y estudiantes, quienes recurren a estas herramientas para gestionar consultas y producir contenidos con mayor rapidez. Este escenario confirma la redefinición de la investigación y el aprendizaje universitario mediante la incorporación de la IAG, pues su adopción masiva está transformando los modos en que se construye, organiza y valida el conocimiento en la educación superior.

A la luz de lo expuesto, el objetivo de esta investigación consistió en indagar los significados en la trama de las experiencias surgidas en el intercambio con herramientas de IA generativa como ChatGPT, Gemini y Copilot con el propósito de comprender cómo dichas interacciones contribuyen en la redefinición de los procesos de investigación y aprendizaje en la vida universitaria. Este proceso investigativo permitió valorar los componentes tales como el sentido ético, responsabilidad y creación de normativas, calidad de los prompts, uso crítico de la IA, autoridad creativa, contrastación y validación de informaciones, promoción del desarrollo cognitivo y originalidad. Esta categorización se ha convertido en fundamento de la propuesta de redefinición de la investigación y el aprendizaje en el ámbito universitario.

Revisión de literatura

La redefinición académica de los procesos de investigación y aprendizaje antes de la aparición de la IAG se había establecido en Venezuela dentro de un enfoque humanista desde la promulgación de la *Ley de Universidades* (Congreso de la República de Venezuela, 1970), la cual estableció en su artículo 1 que “La Universidad es fundamentalmente una comunidad de intereses espirituales que reúne a profesores y estudiantes en la tarea de buscar la verdad y afianzar los valores trascendentales del hombre”. Este espíritu también se evidencia en la *Constitución de la República Bolivariana de Venezuela* (Asamblea Nacional Constituyente, 1999), que reconoce la educación como un derecho humano y un instrumento para el logro del conocimiento científico humanístico y artístico consagrado en el artículo 102. En este orden de ideas, la *Ley Orgánica de Educación* (Asamblea Nacional, 2009), en su Capítulo II, artículo 15, establece que el proceso educativo es, entre otros, holístico, social, integral y humanista, garantizando el pleno desarrollo de la personalidad y el potencial creativo de cada ser humano.

Ciancio & Lucisano (2024) sostienen que los principios humanistas, base del desarrollo moderno, deben recuperarse para reafirmar una visión antropocéntrica y fortalecer el protagonismo humano en la toma de decisiones dentro de los procesos sociales y comunicativos. Mientras que en el marco educativo Estrada Molina et al. (2026) indican que la mediación pedagógica y la educomunicación crítica son esenciales para humanizar la tecnología. Desde un enfoque epistémico sobre la IA Generativa, estos planteamientos conducen al pensamiento reflexivo de acercarnos, desde la educación, a la perspectiva centrada en el ser humano ya que ir mas allá del funcionamiento de la tecnología implica la comprensión de cómo se produce el conocimiento y el lugar que ocupa el ser humano en ese proceso.

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Por su parte, en esta redefinición han sido fundamentales las propuestas de La Organización de las Naciones Unidas para la Educación, Ciencia y la Cultura UNESCO (2023) ha señalado que la educación debe entenderse como un acto profundamente humano, haciendo énfasis igualmente en mantener un enfoque humanista en la tecnología, el conocimiento y el uso de la Inteligencia artificial recomendando especialmente que la tecnología debe estar al servicio del humano y no al revés, apoyada esta actividad en la recomendación sobre la ética de la Inteligencia Artificial. UNESCO (2021).

Ahora bien, la aparición de la inteligencia artificial generativa (IAG) ha transformado de manera significativa las actividades vinculadas con el aprendizaje y la investigación, despertando el interés de diversos actores en torno a los aspectos éticos y regulatorios que implica su uso tanto a nivel nacional como internacional. En particular, en lo referente a la protección de datos, la equidad en el acceso, la transparencia y la seguridad, destaca el Decreto Rectoral sobre el uso de la inteligencia artificial emitido por la Universidad Católica Andrés Bello (2023), en el cual se establecen políticas que orientan y regulan la utilización de esta tecnología en sus actividades académicas e investigativas.

En Venezuela, igualmente, la Comisión Nacional de Tecnologías de la Información (CONATI, 2024) se ha concentrado en generar espacios de discusión y en la construcción de un proyecto de ley de inteligencia artificial que sustente un marco jurídico para su uso en la nación. Por su parte, el Inter-American Dialogue (2025) ha desarrollado iniciativas orientadas a establecer un marco institucional que permita a las instituciones de educación universitaria en Latinoamérica utilizar de manera adecuada la inteligencia artificial en sus actividades características.

Aparicio Gómez (2023) plantea que en el orden de la aplicabilidad de la inteligencia artificial y durante el proceso de aprendizaje se desarrollan competencias requeridas en el ámbito profesional. En coincidencia con este autor, se destaca lo expuesto por Fajardo Aguilar et al., (2023) quienes afirman que el uso adecuado y responsable de la IA en la educación universitaria enriquece el proceso de aprendizaje. En lo que se refiere a la inclusión de la IAG en las actividades de investigación y aprendizaje, Piñate Mendoza (2024) propone la necesidad de diseñar políticas educativas para incorporar adecuadamente la inteligencia artificial en la educación universitaria. Las mismas deben apoyarse en la alfabetización en inteligencia artificial para todos los actores educativos y en el rediseño curricular en el que, manteniendo la integridad académica, se puedan proponer metodologías didácticas y diseños de evaluación enfocados en una nueva generación de usuarios críticos que utilicen estos aplicativos de manera honesta y responsable.

Metodología

En el marco de indagar y comprender las experiencias vividas por los participantes, el estudio se desarrolló desde la fenomenología hermenéutica en seguimiento del método hedeggeriano (Arcila, 2022) constituido por un momento fenomenológico, en el cual las investigadoras se acercaron al fenómeno transitando los testimonios obtenidos y un segundo momento desde donde se organizaron los argumentos de cada informante. En la fase hermenéutica, se interpretaron las ideas dando vida a la construcción compuesta por el tejido organizado de las esencias develadas. La recolección de datos se rigió por los criterios: guión temático, flexibilidad en las entrevistas, selección de informantes según experiencia de uso con las herramientas de IA, registro y transcripción textual. La técnica de recolección empleada durante la investigación fue la entrevista semiestructurada, en concordancia con el método fenomenológico hermenéutico, lo que permitió ahondar

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en las concepciones de los informantes hasta lograr los elementos categoriales de interés para el estudio. Mientras que el contexto en el cual se llevó a cabo la investigación quedó establecido en el nivel universitario en el Estado Carabobo. Se seleccionaron de manera intencional los informantes clave en los estratos de profesores, estudiantes y egresados universitarios. Se consideró un total de doce informantes clave, distribuidos de la siguiente manera: seis docentes en ejercicio, tres estudiantes y tres egresados de diferentes áreas de formación en la Facultad de Ciencias de la Educación de la Universidad de Carabobo.

Resultados y discusion

La interpretación hermenéutica permitió el surgimiento de dos macrocategorías que constituyen los hallazgos de la investigación. La primera: resultados y redefinición o nueva lectura de la investigación y el aprendizaje en el nivel universitario con el uso de la IA, expresa cómo estas tecnologías redefinen prácticas académicas y modos de producción del conocimiento. La segunda: desafíos cognitivos y epistémicos derivados del uso de la IAG en los procesos de aprendizaje revelan exigencias intelectuales. Ambas macrocategorías representan el tejido interpretativo de la propuesta teórico-conceptual que expone una nueva forma de comprender la IA en el contexto de la investigación y el aprendizaje.

Redefinición o nueva lectura de la investigación y el aprendizaje en el nivel universitario con el uso de la IA. Categoría: Antagonías cognitivas y epistémicas

El uso de la IA ocasiona, por una parte, debilidades en el proceso de aprendizaje y, por otra, la activación y motivación de este. Ocurre así la baja retención de los saberes obtenidos con el uso de la IAG debido a que al no ser progresivo ni elaborado el aprendizaje; atravesando procesos como análisis, contrastación de fuentes y producción de los resultados cognitivos; estos no se mantienen en el tiempo; es decir el saber tiende a desaparecer en el corto plazo, lo cual se evidencia en la pérdida de habilidades cognitivas tales como memoria comprensiva, pensamiento crítico y redacción. Por otra parte, emergió de los informantes que consideran la IAG imprescindible para investigar y aprender y, al mismo tiempo, funciona como un activador de saberes previos y de acceso a nuevas nociones en el usuario, promueve un estado de motivación y concentración en el estudiante y el investigador.

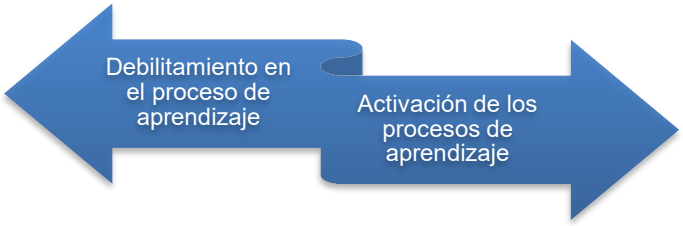


Figura 1. Antagonía cognitiva y epistémica.

En los testimonios también se develaron elementos como la falta de densidad epistémica, producción de conocimiento superficial de carácter estadístico en ocasiones sesgado, carente de la reflexión y profundidad propias de la investigación tradicional. La consistencia académica puede ocurrir conforme el usuario indaga de manera organizada y con prompts cada vez mejor elaborados, lo cual permite,

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aun en las versiones gratuitas de los aplicativos, obtener saberes con cierta profundidad.

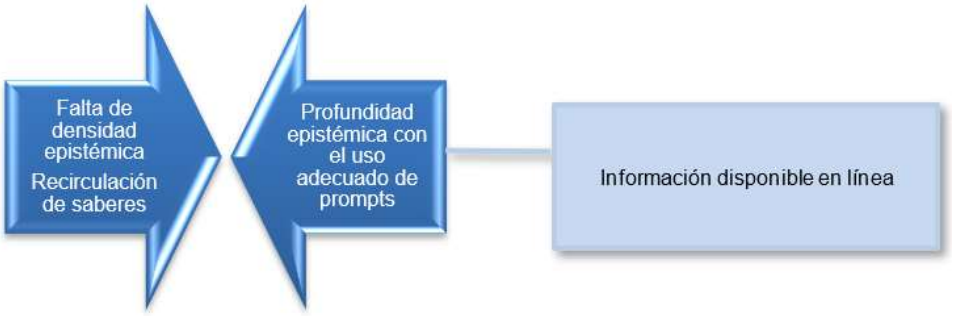


Figura 2. Dinámicas epistémicas en la producción de saberes con IA

Otro elemento develado en relación con la vivencia experimentada quedó registrado por el hecho de que los aspectos emocionales solo están presentes cuando la investigación y el aprendizaje son experimentados entre seres humanos utilizando su inteligencia y no cuando el intercambio es entre el humano y la aplicación. A esto se suma la ventaja que señalan algunos informantes al preferir el aprendizaje e investigación sin sobresaltos que pueden experimentar con la IAG, la cual nunca recrimina al usuario y está programada para responder siempre sin importar si el usuario se equivoca o solicita con insistencia alguna explicación. Con esto desaparece la ocurrencia de desencuentros entre estudiantes y docentes.

Desafíos éticos de autoría y verificación asociados al uso de la IAG en el proceso de aprendizaje e investigación. Categoría: Desafíos éticos, autoría y verificación

Que el algoritmo incluya nociones falsas siempre es una posibilidad, por lo cual se requiere de la contrastación y triangulación con fuentes confiables primarias o secundarias en físico o en línea. De esta manera, es necesario establecer normativas para acordar el respeto a la ética en el uso de la IAG. Así como, más allá de las normas, crear la conciencia y el compromiso en los usuarios para el aprovechamiento virtuoso de los aplicativos y el reconocimiento de este en sus producciones, y evitar así la adjudicación de autorías falsas al promover en su lugar la inclusión de productos elaborados con aplicativos en cualquier construcción presentada por los usuarios. Esto se resume en la necesidad de normar el uso y reconocimiento de la IA dentro de las fuentes de consulta, lo que requiere la promoción del diálogo guiado para determinar fuentes y la precisión de los productos obtenidos a través de la consulta en la IAG.

En relación con el aprendizaje, se develó que buena parte de las actividades pueden ser resueltas con las aplicaciones, lo que privilegia la personalización del proceso. En este sentido, se encontró que, asociada al aprendizaje asistido con IA, son requeridas una reflexión y modificación de los procesos de evaluación, obviando evidencias escritas y prefiriendo defensas, discusiones y desempeños individuales y grupales que permitan fortalecer el desarrollo cognitivo, crítico, argumentativo y productivo autónomo y ético, así como la visibilización del uso de las aplicaciones.

Categoría: La cocreación, desafío entre la inteligencia humana y la inteligencia artificial

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La investigación en todo paradigma incluye entre sus imprescindibles la revisión de la ciencia consolidada. Esto se refleja en los antecedentes de la investigación, en los aspectos legales y en el marco teórico, así como en el establecimiento de los glosarios característicos que proporcionan al investigador y al lector las nociones fundamentales para la comprensión de la investigación. Al respecto se consultan fuentes primarias y secundarias vinculadas que dan soporte y marco epistémico al interés investigativo y que van sustanciando los objetivos o intencionalidades como presupuesto de conocimiento escogido dentro del universo del saber y que debe obedecer al paradigma de investigación en el cual se inscribe la indagatoria y, en consecuencia, debe igualmente caracterizar paradigmáticamente las fuentes consultadas.

Es una preocupación constante que exista una lógica epistémica entre las fuentes consultadas que se hace cada vez más exigente en los estudios de quinto nivel, en los cuales debe verificarse la coherencia epistémica entre los autores referenciados que, de alguna forma, pertenezcan a tradiciones paradigmáticas o puedan entretejer sus postulados de manera sistemática y con argumentos lógicos. El acto reflexivo, previo a la aparición de la IA, podría interpretarse como autoría exclusiva del investigador, aunque haya tejido los resultados de su búsqueda con las voces de teóricos que lo anteceden y de informantes que comparten su visión, condición que es buscada y aprendida para la presentación de resultados y propuestas.

Ahora bien, con la aparición de la IA, la autoría de los productos de investigación debe ser analizada desde una nueva perspectiva en la que el peso de la reflexión podría estar siendo desplazado hacia la acción algorítmica de las aplicaciones de IA generativa, las cuales son capaces de crear contenido generando lenguaje similar al humano de manera argumentada, coherente y como resultado de prompts cada vez más sofisticados. Bajo esta consideración, a continuación, se presenta la formulación de redefinición como una propuesta de nuevo enfoque.

Propuesta de redefinición de la investigación y aprendizaje universitario mediante la incorporación de la IAG

La redefinición de la investigación y el aprendizaje universitario mediante la incorporación de la IAG se concibe como un modo epistémico y ontológico que promueve, el desarrollo de la cognición en pensamiento crítico y creativo, generado a partir del conocimiento del impacto y desafío que plantea el uso de esta en los ámbitos del aprendizaje y la investigación. La misma comprende los siguientes aspectos.

Aspectos éticos

- Cultivar y reforzar el sentido ético del uso de la IA y la relación hombre-máquina para promover mayor presencia de la inteligencia humana cuyo soporte de la IA es inevitable, pero sí reemplazable en el proceso de aprendizaje e investigación, especialmente lo referido a la construcción lingüística prevalente en la escritura.
- Reconocer las políticas de uso de IA y sus principios generales que permitan la valoración de la cocreación de productos intelectuales.
- Establecer orientaciones, lineamientos y políticas que normen el uso de la IA, enfatizando la transparencia en su uso, el reconocimiento de su consulta y la responsabilidad final del autor en la autenticidad de lo escrito.

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Calidad de los prompts

- Tener presente que los prompts simulan el lenguaje humano tras funcionar como un mecanismo de activación cognitiva; esto porque se orientan hacia un modelo específico de razonamiento, tono o profundidad ante la instrucción dada. Un prompt es capaz de modular la profundidad epistémica porque da respuestas según el rigor conceptual, análisis comparativo o explicación estructurada; esto es lo que hace que humanicemos la IA al decir “ella pensó”, “ella me respondió” o, en casos más específicos, “ella redactó justo lo que necesitaba”. Otro aspecto importante del prompt es su capacidad de optimizar su primera redacción; esto ocurre cuando se escribe, por segunda vez, un prompt con mayor precisión y contexto, es decir, la presencia de la reescritura juega un papel preponderante para reducir en su máxima expresión la ambigüedad. Tomando en cuenta que el lenguaje escrito por sí mismo encierra expresiones ambiguas, confusas o inexactas.
- Desarrollo creativo y científico de los prompts o indicaciones para refinar la consulta.
- Discusión en torno a las instrucciones dadas, los resultados obtenidos y su contraste con referentes físicos y digitales, esto en el marco del diseño y estructura intencional de cada prompt.

Uso crítico de la IA generativa

- Pasar del consumo de información a la producción de juicio validado y auditoría epistemológica.
- Realizar interrogación progresiva de los resultados obtenidos a través del uso de la IA.

Uso de fuentes primarias

- Contrastar de forma recurrente las fuentes primarias, la consulta en línea y hacer uso de la triangulación epistémica para lograr el rigor metodológico de la verdad validada en la investigación vs. la verdad estadística producida con el algoritmo de la IA.

Aporte original

- Realizar defensas presenciales de las actividades propias del proceso de aprendizaje precisando, para el nivel universitario, pensamiento y resultados de carácter crítico, propositivo y contextualizado en problemáticas particulares que requieran contextualización.
- Generar actividades en las que se investigue la identificación de estados del arte y vacíos de conocimiento que no maneja la IA.
- Fomentar foros de discusión, virtual y presencial, en el que se argumente, debata y triangule información de la IA con referencias físicas y digitales.
- Identificar errores en los productos obtenidos en la investigación y aprendizaje en el uso de la IA

Discusión

Conocer e investigar dependía de la capacidad de búsqueda y análisis del aprendiz e investigador, mientras que ahora aprender e investigar concierne a la capacidad de asociarse con aplicaciones que realizan tareas cognitivas complejas, donde los resultados deben ser reconocidos en el marco de la cocreación y a la luz de usuarios

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cuyo pensamiento crítico y conocimiento previo de las bondades y debilidades de la IA le permitan generar productos intelectuales acorde con la era de avances y descubrimientos teóricos y tecnológicos que dominan en el presente. Caicedo Pantoja et al. (2025) señalan que en la educación superior el pensamiento crítico se erige como una competencia transversal indispensable para la formación de profesionales capaces de enfrentar los desafíos de la sociedad contemporánea. La formación en IAG está dominada por empresas privadas centradas en habilidades técnicas, por lo que resulta imprescindible promover la integración del pensamiento crítico en los contextos educativos donde se emplea la IA. (Muñoz Martínez et al., 2025). La redefinición de la investigación y el aprendizaje universitario tiene un componente intrínseco, representado en el desarrollo del pensamiento y del conocimiento de la IA. Un buen uso de la IA en los entornos educativos permie a los estudiantes contrastar ideas, identificar sesgos y desarrollar una actitud crítica frente al conocimiento. (Chica-Galeano, 2025).

Conclusión

El estudio concluye que la redefinición de la actividad educativa de investigación y aprendizaje, a partir de la incorporación de la inteligencia artificial en la educación universitaria, queda definido por una nueva manera de actuar, superando el ciclo metodológico de búsqueda y procesamiento de la información disponible en línea, por un proceso de elaboración de prompts o indicaciones que respondan a la inquietud epistémica del investigador. Por su parte, el investigador refina la estructura de la pregunta de manera progresiva hasta lograr, en la iteración, la respuesta acertada. En esta nueva realidad, la interacción humano-IA es determinante para la calidad y profundidad de los resultados, ya que, desde la experticia del usuario, debe generarse la supervisión crítica y el juicio sobre los resultados que arroja el algoritmo, lo que aumenta la validación del conocimiento o información obtenida. De acuerdo con este planteamiento, resulta oportuna la consideración de Sáez-Herráez et al. (2025) quienes proponen un plan integral de formación docente para promover el uso crítico, ético e inclusivo de la IA. Otro aspecto develado se relaciona con la influencia de la IAG en los entornos educativos de investigación y aprendizaje ya que, sin duda ha redefinido la interacción cognitiva, desplazándola de una navegación centrada en la búsqueda de información hacia un proceso de delegación cognitiva en la IA.

El desafío cognitivo y epistémico que se deriva del uso de la IA generativa en el proceso de aprendizaje es esencialmente el difícil seguimiento de la información recibida de la IA, por lo que es importante insistir en la obtención de fuentes fidedignas. En este sentido, el usuario debe tener en cuenta que la IA puede producir información falsa o confusa, que sin duda es superable con una revisión crítica de triangulación y contraste de la información. La propuesta de redefinición como resultado de la indagación de los significados en la trama de experiencias surgidas para comprender las interacciones con herramientas de IA, plantea una nueva lectura de la investigación y del aprendizaje en la educación universitaria, y se compone de los siguientes elementos: el sentido ético y la creación de normativas de uso; la calidad de los *prompts*; el uso crítico de la IA manteniendo la creatividad; el contraste y la validación de la información; y la promoción del desarrollo cognitivo y la originalidad. A partir de estos componentes que redefinen la investigación y el aprendizaje mediado por IAG, se busca fortalecer la cognición, el pensamiento crítico-creativo y el uso ético y responsable de estas aplicaciones. Finalmente, la propuesta se afianza como un aporte teórico-conceptual al promover una nueva forma de comprender la IAG en el contexto de la investigación y el

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aprendizaje, y se consolida como un aporte metodológico y práctico en cuanto a la dinámica epistémica en la producción de saberes con IA.

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