

Prácticas de aprendizaje digital y competencias de investigación: El impacto de las herramientas colaborativas y el Feedback en la educación superior

Digital learning practices and research competencies: The impact of collaborative tools and Feedback in higher education

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Resumen

El estudio tuvo como objetivo determinar la efectividad del uso de herramientas digitales, así como de plataformas de gestión del aprendizaje, herramientas de colaboración y retroalimentación digital para el desarrollo de habilidades básicas de investigación. El estudio se realizó dentro del marco de un enfoque cuantitativo utilizando un diseño cuasiexperimental. La muestra incluyó 250 estudiantes. Se utilizó un cuestionario sobre competencias de investigación, una escala de intensidad de uso de prácticas de aprendizaje digital y una ficha de experto para evaluar tareas de investigación para recopilar datos. La confiabilidad de las herramientas se confirmó mediante el coeficiente alfa de Cronbach ($\alpha = 0,79-0,89$). Se indicó un aumento en el nivel de competencias de investigación después de la implementación de prácticas de aprendizaje digital ($t = 12,84$; $p < 0,001$; d de Cohen = $0,81$). Se encontró una relación positiva entre la intensidad de uso de herramientas digitales y el nivel de competencias de investigación ($r = 0,62$; $p < 0,001$). El análisis de regresión múltiple indicó que el predictor más significativo del desarrollo de competencias de investigación fue el uso de herramientas colaborativas y retroalimentación digital ($\beta = 0,41$). Las conclusiones confirmaron la eficacia de un entorno de aprendizaje digital organizado pedagógicamente para el desarrollo de competencias de investigación.

Palabras clave: aprendizaje semipresencial, educación superior, entorno de aprendizaje digital, prácticas de aprendizaje digital, redacción académica.

Abstract

The study aimed to determine the effectiveness of using digital tools, as well as learning management platforms, collaboration tools, and digital feedback for the development of basic research skills. The study was conducted within the framework of a quantitative approach using a quasi-experimental design. The sample included 250 students. A questionnaire on research competencies, a scale of intensity of use of digital learning practices, and an expert card for assessing research tasks were used to collect data. The reliability of the tools was confirmed by Cronbach's alpha coefficient ($\alpha = 0.79-0.89$). The indicated an increase in the level of research competencies after the implementation of digital learning practices ($t = 12.84$; $p < 0.001$; Cohen's $d = 0.81$). A positive relationship was found between the intensity of use of digital tools and the level of research competencies ($r = 0.62$; $p < 0.001$). Multiple regression analysis indicated

that the most significant predictor of the development of research competencies was the use of collaborative tools and digital feedback ($\beta = 0.41$). The conclusions confirmed the effectiveness of a pedagogically organized digital learning environment for the development of research competencies.

Keywords: academic writing, blended learning, digital learning environment, digital learning practices, higher education.

Introduction

In the current conditions of digital transformation of education, the formation of research competencies of education seekers has acquired special importance. The transition to a knowledge economy, the rapid development of digital technologies and the growing role of interdisciplinary approaches have led to the need to train specialists who would be able to reproduce knowledge and independently generate it, critically interpret and apply it in new contexts of digitalization. Therefore, research competencies were considered a key component of academic and professional training (Aliu et al., 2022). They ensured readiness for scientific activity, innovative thinking and making informed decisions. The digital educational environment has opened up new opportunities for the development of such competencies. The use of online platforms, learning management systems (LMS), collaboration tools, artificial intelligence and data analytics has significantly contributed to the activation of students' cognitive activity, expanding access to scientific resources and the formation of research skills in an interactive format (Leichsenring & Clauss, 2024; Mason et al., 2023). At the same time, the effectiveness of such tools depended on the pedagogical design of the educational process, in particular, the integration of research-oriented methods, problem-based learning, project activities and collective construction of knowledge (Osuna-Juárez & González-Castellano, 2023).

Despite a significant number of studies devoted to the digitalization of education and the development of research skills, many unresolved issues remain. First of all, there is a lack of empirically substantiated educational practices in the digital environment that are most effective for the formation of research competencies. Research that would combine pedagogical experiment with quantitative assessment of results was also limited. There was a shortage of scientific works that analyzed the impact of specific digital tools in combination with methodologically structured educational interventions.

Therefore, the scientific problem of the study was to determine the effectiveness of educational practices that would be aimed at developing research competencies of education seekers in a digital educational environment.

The purpose of the article is to empirically study the effectiveness of educational practices that were focused on the development of research competencies of education seekers in the digital environment, to identify the most effective pedagogical approaches and digital tools that contributed to this process.

RQ1: What is the level of research competencies of education seekers before and after the implementation of digital learning practices?

RQ2: Is there a relationship between the intensity of use of digital learning practices and the level of research competencies of education seekers?

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RQ3: What components of the digital learning environment (shared tools, digital feedback, overall level of platform use) influence the development of research competencies?

Research hypotheses:

H1: The implementation of digital learning practices will increase the level of research competencies of education seekers.

H2: The frequency of use of shared digital tools, intensity of digital feedback, and overall level of digital platform use will be important predictors of the development of research competencies.

The proposed study had theoretical and practical significance. Theoretically, it expanded the understanding of the mechanisms of forming research competencies in the digital era, and practically, it proposed proven approaches to organizing the educational process that can be used in higher education institutions in the future.

Literature Review

Research competence: theoretical foundations and formation

In modern studies, the development of research competencies of scientists has been shown as one of the key outcomes of higher education, especially when the conditions of digitalization of the educational environment are taken into account (Pérez-Valls et al., 2023; Pérez Estébanez & Pastor Estébanez, 2025). Within the framework of the competency approach, research competencies are interpreted as an integrative formation that includes the ability to formulate a problem, search for and critically analyze information, interpret data, and present research results (for example, the role of social interaction and an activity-based approach in the formation of complex cognitive skills has been repeatedly emphasized).

Researchers also drew attention to the fact that an important characteristic of research competence is its interdisciplinary nature, since it consists of methodological literacy, analytical thinking, and the ability to work with data (Sposato, 2024). Of particular importance is the development of the skills to formulate research questions, build hypotheses, and choose adequate methods of data collection and analysis. Therefore, we can conclude that this competence acts as a metacompetence, which consists of cognitive, operational, and value factors on the path to the development of professional activity. However, as other scientists have noted, the skills of working with large data sets and the use of digital analysis tools have become significantly more active. Accordingly, the ability to select information and identify cognitive biases has begun to play a special role.

In these conditions, research competence requires high-quality mastery of knowledge and involvement of education seekers in practical research activities (Kulichenko et al., 2018; Kulichenko et al., 2023). In this system, it is important not only to carry out individual tasks, but also to include students in the full cycle: problem formulation, analysis and interpretation of data with subsequent reflection (Omrany et al., 2025). Such an approach will allow to form the logic of scientific knowledge and will contribute to the formation of sustainable strategies.

Effective approaches in this direction are problem-oriented learning, project activities, case method and research-oriented learning. These approaches require an active position of the seeker as a subject of knowledge. In addition, in these formats, independence in choosing research methods, working with uncertainty and

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the need for reasoned justification of decisions taken are of particular importance.

The impact of digitalization on the formation of research competence

A significant number of modern works have focused on the potential of the digital educational environment for the development of such competencies. Research in the field of digital pedagogy and blended learning has demonstrated that the combination of traditional and digital forms of learning has significantly contributed to the development of critical thinking, autonomy, and research skills (Sposato, 2024; Zarceño García de Soriano et al., 2024). At the same time, the effectiveness of digital technologies largely depended on their pedagogically justified use (Austin Henry & Beserra, 2022). That is, it was not only about the level of technological equipment.

A separate area of research was related to the inquiry-based learning conception, which was considered one of the most effective approaches to developing research skills (Dembitska et al., 2024; Ma & Fang, 2023). It concerned digital tools that served as environments for information search, data organization, collaboration, and reflection. Studies have shown that the use of digital platforms, collaborative writing tools, and online feedback positively affected the quality of students' research activities (Omran et al., 2025; Santos et al., 2021).

In addition, scientists drew attention to the fact that immersive and simulation technologies had significant potential in the development of research competence. In particular, they make it possible to model complex, multifactorial research situations in a controlled educational environment. Their use also creates special conditions for practicing the skills of data analysis in real time, decision-making under conditions of limited information and time (Dembitska et al., 2024). In addition, such environments influence the formation of research reflection, and allow students to observe their own actions, evaluate their effectiveness and adjust behavioral strategies.

At the same time, scientists drew attention to the fact that an important element in this system is also the organization of feedback, which allows students to understand both the process and the results of their own research activities. Regular analytical reflection, discussion of results in a group and evaluation of alternative approaches allow the formation of critical thinking and the ability to argue (Ma & Fang, 2023).

Therefore, as can be seen, the use of interactive formats can ensure the mastery of research methods and form the autonomy of thinking.

At the same time, more critical positions on the digitalization of education were observed in the scientific literature. In particular, scientists emphasized that the use of digital tools in itself did not guarantee the development of research competencies and could be effective only under the conditions of structured pedagogical design, scaffolded support, and an active role of the teacher. Some studies also pointed to the risks of superficial knowledge acquisition and a decrease in the depth of analysis with excessive use of digital resources (Ramírez Heredia et al., 2025).

Thus, modern scientific discourse has shown that the digital educational environment has significant potential for the development of research competencies, but the effectiveness of this process was determined not by technologies as such, but by their integration into pedagogically designed educational practices. This logic became the theoretical basis for the study, which also aimed to eliminate a significant gap - the lack

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of empirical measurements of the use of digital technologies.

Methodology

Research design

The study was conducted based on a quantitative approach using a quasi-experimental pre-test/post-test design with a comparison of results before and after the implementation of a model of specially formed educational practices in a digital environment. The chosen design made it possible to empirically assess changes in the level of research competencies of education seekers based on specially organized digital educational practices. Despite the use of a quasi-experimental pre-test/post-test design without a control group, this approach had a methodological justification. The formation of a control group was limited due to organizational and ethical factors, because all participants were involved in the educational process, in which digital learning practices were an integral part of the training courses.

To minimize threats to internal validity, particularly the maturation effect, several procedures were used. First, the duration of the intervention was limited to 8–10 weeks, which reduced the likelihood of significant changes that were not related to the influence of the studied practices. Second, the analysis was carried out considering control variables (age, level of education, previous research experience, and level of digital literacy). This approach made it possible to partially compensate for the absence of a control group. Third, the use of a combination of self-assessment and expert assessment increased the objectivity of the results.

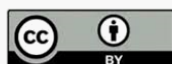
The study considered the effectiveness of various activities and practices: working with digital platforms for searching and analyzing sources, conducting mini-research in an LMS environment, using collaborative academic writing tools, digital feedback forms, online discussions, electronic research diaries, and tools for visualizing and presenting results. The design used made it possible to combine the assessment of the initial level of research competencies with further analysis of changes after the intervention.

The independent variable was the implementation of a set of educational practices in a digital environment. The dependent variable was the level of development of research competencies of education seekers. The control variables included age, level of education, previous experience in research activities, and level of digital literacy.

Participants

The study involved 250 students from educational institutions in Ukraine. The sample was selected based on purposive sampling, involving individuals who studied in a digitally supported educational environment and participated in educational activities related to research work. The sample included undergraduate and graduate students. To ensure analytical representativeness, participants were divided by gender, age, level of education, and previous experience using digital tools in education. This approach also allowed us to explore the heterogeneity of the educational audience and reduce the risk of bias.

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Table 1.
Characteristics of participants (N = 250)

Variable	Category	n	%
Gender	Female	148	59.2
	Male	102	40.8
Age	17–19 years	74	29.6
	20–22 years	109	43.6
	23 years and older	67	26.8
Level of education	Bachelor's degree	172	68.8
	Master's degree	78	31.2
Experience with digital learning tools	Low	52	20.8
	Medium	121	48.4
	High	77	30.8
Prior research experience	None / minimal	96	38.4
	Moderate	103	41.2
	Advanced	51	20.4

The study involved students from several higher education institutions in Ukraine, representing various majors (including humanities, social sciences, and technical fields). The sampling was purposive, which was due to the need to involve participants who studied in conditions of digital educational practices. At the same time, this approach limited the possibility of generalizing the results to the entire higher education system in Ukraine, which had to be taken into account when interpreting the data obtained.

Tools and validation

Various instruments were used to collect empirical data.

The questionnaires were adapted from existing structures and improved to reflect the context of digital learning environments, and some parts were developed by the authors.

The main instrument was a structured questionnaire that measured the level of development of research competencies. This questionnaire identified the following aspects:

- the ability to formulate a research problem;
- the ability to define a goal, objectives and hypotheses;
- the skills of searching, selecting and critically evaluating sources;
- the ability to analyze and interpret data;
- academic writing skills;
- the ability to present research results;
- reflection on one's own research activities.

The questionnaire items were rated on a five-point scale (1 – completely disagree; 5 – completely agree). The final score indicated the overall level of development of research competencies.

The scale of intensity of use of digital learning practices was to determine the frequency and intensity of participants' use of digital tools in research-oriented learning. It included blocks on:

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use of LMS;
digital libraries and academic databases;
collaborative writing tools;
online communication and discussion tools;
digital platforms for data processing and visualization;
electronic feedback.

An important tool in the study was the expert card for evaluating research tasks. It was used to ensure the objectivity of self-assessment data, expert assessment of mini-research or research tasks completed by participants was used. This card was evaluated according to the criteria of research logic, quality of argumentation, correct use of sources, data analysis and quality of presentation of results.

A separate block of the toolkit contained a socio-demographic questionnaire, which included questions on age, gender, level of education, previous experience in research activities and level of digital literacy.

To ensure the methodological quality of the tool, a multi-stage validation was carried out. In particular, content validity was first ensured: the initial version of the questionnaire was developed based on an analysis of scientific literature on the structure of research competencies and the digital learning environment. After that, the tool underwent expert evaluation with the participation of 5–7 specialists in the field of pedagogy, educational technologies and research methodology. The experts assessed the relevance, clarity and compliance of the items with the research goal.

Subsequently, a pilot study was conducted on a small group of participants (for example, 25–30 people) who were not included in the main sample. Based on the results of the pilot study, the wording of the items was clarified and ambiguities were eliminated.

The reliability of the tools was determined using Cronbach's alpha coefficient. In particular, a value of $\alpha \geq 0.70$ was considered acceptable, $\alpha \geq 0.80$ was considered good. The obtained values ranged from 0.79–0.89. This indicated good internal consistency. The suitability of the data for factor analysis was confirmed by the Kaiser–Meyer–Olkin coefficient ($KMO = 0.87$) and the statistically significant result of the Bartlett test of sphericity ($\chi^2 = 2154.36$, $p < 0.001$).

The CFA results showed acceptable model quality:

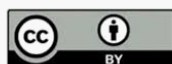
$\chi^2/df = 2.38$, CFI = 0.93, TLI = 0.91, RMSEA = 0.054. These indicators correspond to the recommended threshold values.

Inter-expert consistency was determined for the expert assessment map. The value of Cohen's Kappa coefficient was 0.76. This indicated a high level of consistency of the estimates.

Research procedure

In order to increase the reproducibility of the study, the concept of “digital learning practices” was operationalized. Within the framework of the proposed article, this concept is considered as a structured set of pedagogical actions implemented using digital tools in the process of research-oriented learning.

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Table 2.
Structure of digital learning practices within the intervention

Practice	Digital tools	Frequency	Expected result
Source search and analysis	Google Scholar, Scopus, цифрові бібліотеки	weekly	development of information literacy
Mini-research	LMS (Moodle/Canvas)	2–3 times per course	formation of research logic
Collaborative academic writing	Google Docs, Overleaf	continuously	development of academic writing skills
Online discussions	форуми LMS, Zoom, Teams	weekly	development of critical thinking
Digital feedback	LMS, Google Forms	after each assignment	reflection and correction of activities
Data visualization	Excel, Power BI, Canva	2–3 times	development of analytical skills
Electronic research diaries	Notion / LMS	continuously	development of reflection

All of these practices were implemented in a standardized format over 8–10 weeks with the same intensity and time frame for all participants, ensuring comparability of the results.

The study was conducted in several consecutive stages.

At the first stage, participants were informed about the purpose of the study, the principles of voluntary participation, confidentiality and anonymity of data. After obtaining informed consent, they filled out an entry questionnaire (pre-test), which allowed us to record the initial level of research competencies and the intensity of the use of digital teaching practices.

At the second stage, an educational intervention was implemented, which required the systematic use of digital teaching practices for 8–10 weeks. The intervention included:

implementation of research mini-projects;
search and critical analysis of sources in digital databases;
joint writing of texts in cloud environments;
participation in thematic forums and discussions;
use of digital tools for collecting, processing and visualizing data;
receiving formative feedback from the teacher via electronic platforms.

Further, after the intervention, a final evaluation (post-test) was conducted using the same or equivalent instruments. Additionally, expert evaluation of the completed research tasks was implemented. In order to minimize methodological risks, all participants worked in comparable organizational conditions. At the same time, digital learning activities had a unified structure, time limits and evaluation criteria.

Data analysis

Data processing was implemented using the SPSS statistical software.

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In particular, the descriptive statistics method was initially used, on the basis of which the mean values, standard deviations, minimum and maximum values were calculated.

Before conducting the inferential analysis, assumptions were made regarding the normality of the distribution and homogeneity of variances using the Shapiro-Wilk and Levene's tests. In order to assess the changes between pre-test and post-test, it is advisable to use:

paired t-test - if the distribution is close to normal;
Wilcoxon test - if the data do not meet the parametric assumptions.

In order to determine the role of digital learning practices on the development of research competencies with the control of background variables, the following were used:

multiple linear regression analysis;
ANCOVA, if it is necessary to compare the final indicators with the control of pre-test results;
Pearson or Spearman correlation analysis to determine the relationship between the intensity of use of digital tools and the level of research competencies.

Statistical significance was established at the $p < 0.05$ level. Also calculate the effect size: Cohen's d, partial eta squared (η^2) and R^2 .

Overall, the study was created in compliance with the basic ethical principles of pedagogical and social research: voluntary participation, informed consent, confidentiality, anonymity and the right of participants to refuse participation at any stage. The collected data were used exclusively for scientific purposes.

It is important to note that the empirical data were generated based on a combination of self-assessment and external expert assessment. The main data set (about 70%) was obtained from the questionnaire. The other 30% were the results of expert assessment of completed research tasks. Therefore, this made it possible to combine the subjective perceptions of education seekers about their own competencies with a more objective assessment of their real educational results. To check the consistency of the results, a correlation analysis was performed between the indicators of self-assessment and expert assessment. The results obtained indicated the presence of a statistically significant positive relationship between these indicators. Under such circumstances, confirmation of the validity of the instruments used was obtained, and the risks of bias associated with self-reporting were reduced.

Results and Discussion

In the first stage, a comparative analysis of the means and standard deviations before (pretest) and after (posttest) was carried out. Subsequently, a paired t-test was used to test the statistical significance of the differences between the two dimensions. A positive trend was observed in all the main components of research skills. The greatest improvement was observed in the following components: searching and critical analysis of sources, academic writing, and presentation of research results. The overall integral indicator of research competencies also increased significantly after the intervention (see Table 3).

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Table 3.

Descriptive statistics of research competency indicators before and after the intervention

Research Competence Component	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD
Formulation of Research Problem	3.08	0.63	3.69	0.58
Statement of Goal, Objectives and Hypotheses	3.11	0.60	3.74	0.55
Search and Critical Analysis of Sources	3.19	0.57	3.88	0.52
Data Analysis and Interpretation	3.05	0.61	3.70	0.56
Academic Writing	3.14	0.59	3.83	0.51
Presentation of Research Results	3.09	0.62	3.79	0.54
Reflection on Research Activity	3.17	0.56	3.82	0.50
Overall Score	3.12	0.54	3.78	0.49

As shown in Table 3, the mean values after the intervention exceeded the corresponding values before the intervention for all the components studied. The highest post-test score was recorded for the component "Searching and Critically Analyzing Sources" (M = 3.88; SD = 0.52). At the same time, the lowest, although also higher than the pre-test, was found for the component "Formulating a Research Problem" (M = 3.69; SD = 0.58). The total score increased from 3.12 to 3.78 (see Figure 1). Such data indicated an increase in the research competencies of the participants.

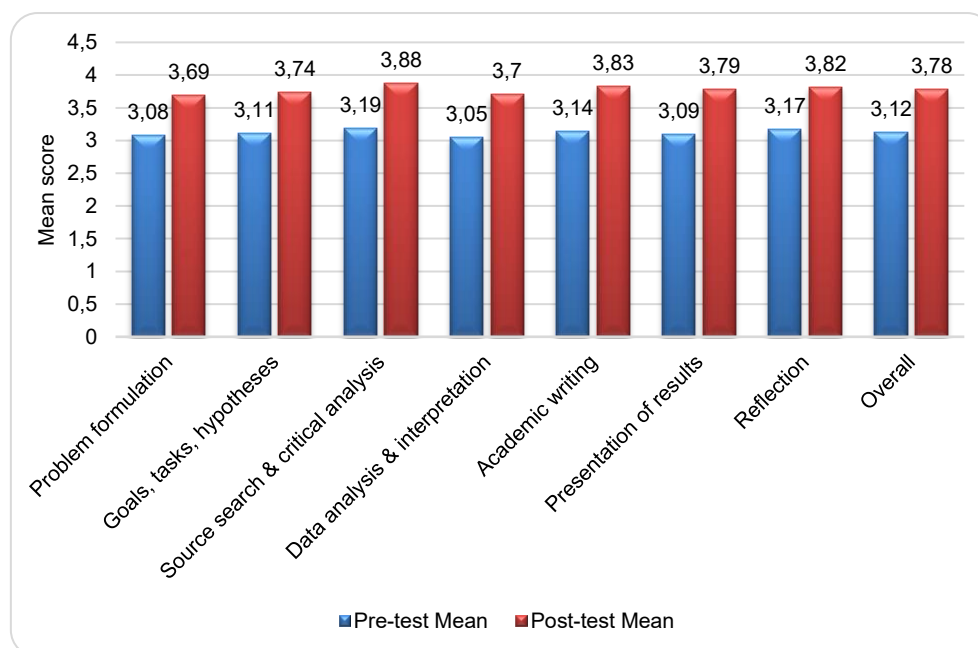


Figure 1. Comparison of mean values of research competency components before (pre-test) and after (post-test) implementation of digital practices.

At the same time, a paired t-test was conducted to check whether the differences found were statistically significant. The results are presented in Table 3. The results of the paired t-test showed that the differences between pre-test and post-test are significant for all components of research competencies ($p < 0.001$). The largest

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changes were recorded for the components “Presentation of research results” and “Academic writing”.

The graphical representation of the data in Figure 1 demonstrates the positive dynamics of the development of research competencies of education seekers after the implementation of digital learning practices. Moreover the post-test values exceeded the corresponding pre-test indicators for all components.

Table 4.
Paired t-test results for research competency indicators

Indicator	Mean difference	t	df	p	Cohen's d
Formulation of the research problem	0.61	10.42	249	<0.001	0.66
Statement of the goal, objectives and hypotheses	0.63	10.95	249	<0.001	0.69
Search and critical analysis of sources	0.69	11.84	249	<0.001	0.75
Analysis and interpretation of data	0.65	10.88	249	<0.001	0.69
Academic writing	0.69	11.97	249	<0.001	0.76
Presentation of research results	0.70	12.11	249	<0.001	0.77
Reflection on research activity	0.65	11.02	249	<0.001	0.70
Overall indicator	0.66	12.84	249	<0.001	0.81

The overall integral indicator also indicated a statistically significant increase ($t = 12.84$; $p < 0.001$). The obtained value of Cohen's $d = 0.81$ indicated a large effect size. Therefore, the implemented digital teaching practices had a positive impact on the development of research competencies of education seekers.

The study also conducted a correlation analysis, covering general indicators and main components of the digital learning environment and research competencies. This approach made it possible to establish the fact of the existence of a connection and to detail its structure.

Before conducting the analysis, the assumptions regarding the normality of the distribution (Shapiro–Wilk) were checked, which did not reveal statistically significant deviations ($p > 0.05$). The Pearson correlation coefficient was then applied (see Table 5).

Table 5.
Matrix of correlations between digital learning practices and elements of research competencies

Variables	1	2	3	4	5	6	7	8
1. Digital practices (overall)	1							
2. Collaborative tools & feedback	0.71**	1						
3. LMS & platform use	0.66**	0.63**	1					
4. Problem formulation	0.48**	0.51**	0.42**	1				
5. Goals & hypotheses	0.52**	0.55**	0.47**	0.64**	1			
6. Source analysis	0.67**	0.69**	0.61**	0.58**	0.63**	1		
7. Data analysis	0.59**	0.62**	0.54**	0.56**	0.60**	0.68**	1	
8. Academic writing & presentation	0.64**	0.68**	0.57**	0.53**	0.61**	0.66**	0.72**	1

Note: $p < 0.001$

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As can be seen from Table 5, all correlation coefficients are positive and significant. Thus, it is clear that there is a systemic relationship between digital teaching practices and the development of research competencies.

The strongest relationships were recorded between the use of collaborative tools & feedback and source analysis ($r = 0.69$), the use of the same tools and academic writing ($r = 0.68$), the general level of digital practices and source analysis ($r = 0.67$).

This made it possible to determine that it is interactive and collaborative digital tools that have the greatest impact on the formation of research skills.

At the same time, the least pronounced, although between digital practices and the formulation of the research problem ($r = 0.48$). This indicated the complexity of developing this competence.

To determine which components of the digital learning environment have the greatest impact on the development of students' research competencies, a multiple linear regression analysis was performed, which allowed us to determine the contribution of individual components of digital learning practices to explaining the variation. The multicollinearity of the independent variables was then tested. The VIF values did not exceed 2.1. Therefore, there were no critical multicollinearity problems. The linearity and homoscedasticity of the residuals were also tested, which met the statistical assumptions (see Table 6).

Table 6.
Results of multiple linear regression analysis

Predictor	B	Std. Error	Beta (β)	t	p-value
Collaborative tools & feedback	0.47	0.08	0.41	5.88	<0.001
LMS & platform use	0.21	0.07	0.23	3.12	0.002
Digital interaction intensity	0.18	0.06	0.19	2.95	0.004
Age (control)	0.05	0.06	0.06	0.84	0.401
Level of education (control)	0.03	0.05	0.04	0.61	0.543
Digital experience (control)	0.07	0.06	0.08	1.12	0.264

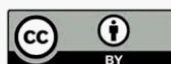
Note: R^2 0.48; Adjusted R^2 0.46; F 38.91; df (6, 243); p-value <0.001

Therefore, the model is significant ($F = 38.91$, $p < 0.001$) and explained 48% of the variation in the level of research competencies.

The results of the regression analysis indicated that the most significant predictor of the development of research competencies is the use of collaborative tools and digital feedback ($\beta = 0.41$, $p < 0.001$). This may indicate that the active involvement of students in collaborative environments and systematic feedback significantly enhance the formation of research skills.

The overall level of use of digital platforms (LMS) was also an important predictor ($\beta = 0.23$, $p = 0.002$). Separately, the intensity of digital interaction had a significant impact ($\beta = 0.19$, $p = 0.004$), which emphasizes the role of communication, discussion and active participation in the learning process. At the same time, control variables (age, education level, previous digital experience) did not have a statistically significant impact (see Figure 2).

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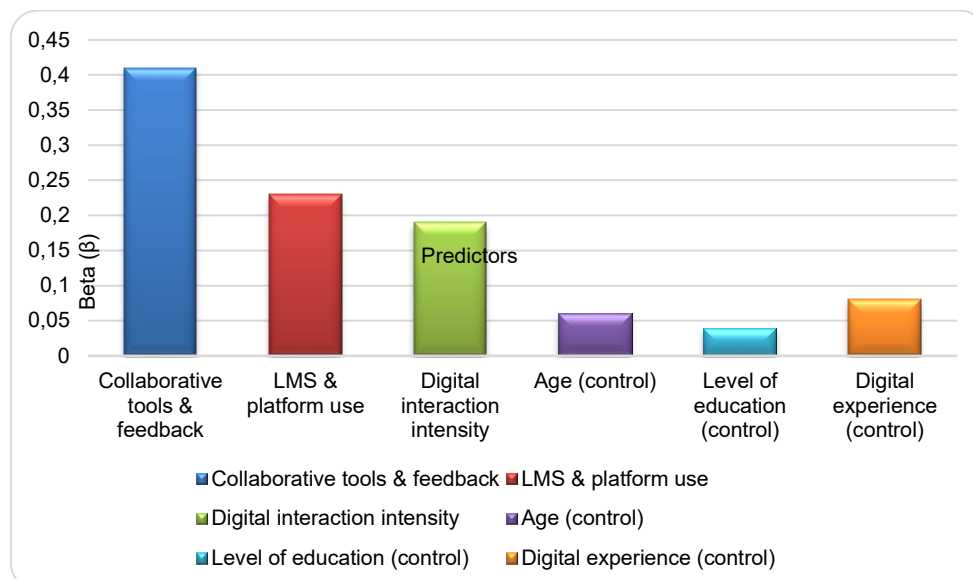


Figure 2. Standardized regression coefficients (β) of predictors of research competence development.

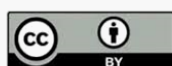
The graphical representation of the standardized regression coefficients (Figure 2) clearly indicated the relative strength of the influence of individual components of the digital learning environment. As can be seen from figure 2, the largest contribution to explaining the variation in the dependent variable is the use of collaborative tools and digital feedback. This indicated their important role in the formation of research skills.

Discussion

The results obtained showed that the implementation of digital learning practices is accompanied by a statistically significant increase in the level of research competencies of education seekers by the general integral indicator and by individual components. Such dynamics are generally consistent with modern scientific approaches, according to which digital and blended learning may not be effective in itself. Therefore, it is specifically designed to develop higher cognitive skills, in particular critical thinking, creativity, analytical work with information and reflection (Sohail & Gupta, 2024). Also, according to some scientists, research competence is important for solving a wide range of educational and life tasks. Therefore, it should be formed on an interdisciplinary basis as a specially structured set of qualities that allow students to effectively participate and act in various life situations. In this sense, our results supported the conclusions of other scientists that the most promising for the development of higher-order thinking skills were blended and flipped formats (Alam & Mohanty, 2023; Chovriy et al., 2025). At the same time, fully online learning did not always demonstrate better results.

Positive changes in the proposed study are especially noticeable in the components related to the search and critical analysis of sources, data analysis, academic writing and presentation of results. This is well explained in the modern literature on inquiry-based learning (Bojórquez-Roque et al., 2024; Hattab, 2023). In particular, a systematic review of the roles of digital technologies in IBL demonstrated that digital tools most often functioned as means of accessing content, collecting data, organizing ideas, exchanging information, and receiving feedback (Filippou et al., 2025; Kuzminska et al., 2021). It is this functional multicomponent

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nature of the digital environment that may explain why the greatest gains in our sample were not observed in an isolated skill, but in several interconnected components of research activity.

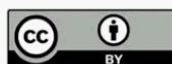
The proposed results are also consistent with recent empirical evidence on the relationship between digital competence and educational achievement. For example, studies have shown that students' overall digital learning competence is positively associated with academic performance (Inamorato dos Santos et al., 2023; Maricato et al., 2026). The most notable contributions were made by technical, managerial and assessment components. This is important for interpreting the data obtained because digital practices also served as a channel for accessing materials, and became an environment for self-regulation, assessment and organization of research work (Ismail et al., 2026; Spante et al., 2018; Polyezhayev et al., 2024). Therefore, the proposed research results supported the theory that the development of research competences in the digital environment did not occur solely due to the availability of platforms, but as a result of the formation of skills for managing one's own educational and research activities (Ashraf et al., 2022).

Of particular note is the increase in academic writing and presentation of research results. In this respect, the proposed findings are consistent with studies that have highlighted the role of digital self-efficacy, genre awareness, collaborative writing and reflective revision in the formation of academic writing competence. In particular, recent studies have shown high explanatory power of a model that combines digital self-efficacy, collaborative writing and reflective editing in the framework of academic writing competence (de Alwis et al., 2025). This correlated well with the results obtained: improvement in writing was one of the most noticeable effects of the digital intervention, which was probably related to the combination of collaborative work, gradual text revision and regular feedback.

A similar logic has been supported by other researchers. Systematic reviews have shown that online peer assessment is associated with both cognitive outcomes and behavioral and affective consequences: increased engagement, communication, teamwork, motivation, self-esteem and autonomy (Palamar et al., 2023). At the same time, the authors emphasized that the effect depended on the characteristics of the students, the design of the tasks, the platform and the technological support (Sliwka et al., 2023). This was well explained by the data obtained: the positive impact of digital practices probably arose not simply due to the use of technology. Rather, it was due to the pedagogically structured application in the system of tasks, which combined collaborative work, formative feedback and step-by-step research activities. At the same time, the results obtained should not be interpreted as evidence that any expansion of digitalization would automatically improve research skills. A more cautious position has been traced in the scientific literature (Lidolf & Pasco, 2020; Zhao et al., 2021). In particular, several reviews have emphasized that digital tools could enhance the quality of writing, the structure of the presentation and the availability of support. However, their excessive or uncritical use can form a dependence on external prompts and weaken the development of one's own critical thinking and creativity. Therefore, the results of the proposed study should be interpreted in line with the concept of pedagogically guided digital support, where the key elements were dosage, scaffolded feedback, a clear structure of tasks, and the reflective activity of students.

Another important aspect was that in the proposed study, less pronounced growth was observed in the components that were related to the formulation of the research problem. This also did not contradict modern scientific ideas. Modern scientists

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emphasized that online and digital formats had the potential to develop higher-order thinking skills (Kurebay et al., 2023; Boichenko et al., 2023). However, this potential was realized unevenly for different types of cognitive operations; the most complex stages, which were related to the formulation of the problem, conceptualization, and original research design, usually required more intensive teaching support (Sillat et al., 2021; Turabay et al., 2023; Pichkur et al., 2023). Accordingly, the results obtained gave reason to assume that it was precisely for the development of problematization, construction of research logic and formation of hypotheses that digital tools should be combined with more targeted mentoring by the teacher. Overall, the study supported the modern scientific position, according to which the digital environment was a productive resource for the development of research competencies if it was integrated into learning as a space for searching for sources (Guillén-Gámez et al., 2021; Colás-Bravo et al., 2021). At the same time, the proposed results also clarified the following position: the greatest effect was observed where digital tools were supported by specific research actions and interactions. Therefore, the obtained findings are considered as an argument in favor of the transition from “digitalization as technical equipment” to “digitalization as pedagogical design of research-based learning”.

Thus, hypothesis H1, which predicted that the implementation of digital learning practices would improve the level of research competencies of education seekers, was confirmed. The results of the paired t-test indicated significant differences between pre- and post-test scores for all components of research competencies ($p < 0.001$). The effect size value (0.81) indicated a strong practical effect of the intervention.

Hypothesis H2 was also confirmed. The results of the correlation analysis indicated a moderately positive relationship between the variables ($r = 0.62$, $p < 0.001$). This indicated the systemic nature of the influence of the digital environment.

In addition, the results of the multiple regression analysis allowed us to clarify the structure of this influence: the most significant factors were the use of shared digital tools and feedback ($\beta = 0.41$, $p < 0.001$), the overall level of use of digital platforms ($\beta = 0.23$, $p = 0.002$). The control variables did not demonstrate a statistically significant influence.

Despite the significant results obtained, the study had certain limitations that should be taken into account when further interpreting the data. First, the quasi-experimental design used without a control group limited the possibility of unambiguously establishing cause-and-effect relationships. Second, some data were obtained using self-assessment tools, which could be accompanied by the effect of social desirability or subjective inflation of the results. Third, the study was conducted on a relatively large sample of participants, which may limit the possibility of generalizing the results to other educational contexts. Furthermore, the use of purposive sampling limited the representativeness of the results, so their transfer to the broader student population required caution.

Conclusions

Therefore, the proposed results demonstrated that the implementation of digital learning practices was accompanied by a statistically significant increase in the level of research competencies by the general integral indicator and by individual components. The most pronounced effect was recorded in the area of searching and critical analysis of sources, academic writing and presentation of research results. A moderately strong positive relationship was found between the intensity of use of digital learning practices and the level of research competencies. This indicated the

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systemic nature of the influence of the digital educational environment.

The results of multiple regression analysis demonstrated: the most significant predictors of the development of research competencies were the use of shared digital tools and feedback, the overall level of use of digital platforms.

At the same time, the smallest growth was recorded for the "Problem Formulation" component. Thus, identifying scientific contradictions and formulating research questions is one of the most difficult components of research competence. Therefore, the use of digital educational platforms in itself will not provide sufficient conditions for the effective development of research problem-setting skills. To increase the level of formation of this competence, it is advisable to integrate specialized educational activities into the educational process that are aimed at the formation of research thinking: analysis of real and simulated problem situations, case methods, project-research tasks, exercises in formulating research questions and hypotheses, as well as collective discussion and expert review of research ideas. In addition, systematic mentoring of students, consisting of individual consultations, providing feedback on the quality of formulated research problems, and support at the stages of research design, can play an important role.

In general, the study confirmed that the effectiveness of the digitalization of education was determined not only by the availability of technologies, but also by their pedagogically justified integration into the research-oriented educational process. The digital environment has been a productive tool for developing research competencies, if it is used as a space for active, reflective and collaborative learning activities. The results obtained could be used to improve educational programs, develop digital courses and form strategies for developing research competencies in a modern educational environment.

The results also opened up a number of promising directions for further scientific research in the field of developing research competencies in the digital educational environment. First, it would be advisable to conduct research using an experimental design with a control group, which would allow us to more clearly establish the cause-and-effect relationships between the use of digital educational practices and the development of research competencies.

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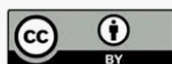
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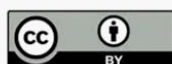
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