MULTIDISCIPLINARY SCIENTIFIC RESEARCH
BJMSR VOL 11 NO 1 (2026) P-ISSN 2687-850X E-ISSN 2687-8518
Available online at https://www.cribfb.com
Journal homepage: https://www.cribfb.com/journal/index.php/BJMSR
Published by CRIBFB, USA

FORMATION OF DIGITAL COMPETENCES OF STUDENTS IN THE SYSTEM OF HIGHER PEDAGOGICAL EDUCATION

Zabiyeva Kamshat Kazbekovna [(a)] *Zhiyembayev Zhomart Tumarbekovich* [(b)1] *Seitova Sabyrkul* [(c)] *Kalzhanova Gulmira Kenesovna* [(d)] *Yesseikyzy Aiym* [(e)]

[(a)] *Lecturer, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan; E-mail: kamshatzabieva@gmail.com*
[(b)] *Lecturer, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan; E-mail: zht.zhiembayev@gmail.com*
[(c)] *Professor, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan, E-mail: s.m.seitova@gmail.com*
[(d)] *Director of the Center for Competencies and Additional Education, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan, E-mail: kgk67@mail.ru*
[(e)] *Lecturer, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan; E-mail: aiym.yesseykyzyy@gmail.com*

ARTICLE INFO

Article History:

Received: 28th August 2025
Reviewed & Revised: 28th August 2025 to 6th December 2025
Accepted: 10th December 2025
Published: 12th December 2025

Keywords:

Digital Competences, Higher Pedagogical Education, Digital Literacy, Professional Training, Innovative Teaching

JEL Classification Codes:

I21, I23, I25, O33, M15

Peer-Review Model:

External peer review was done through double-blind method.

ABSTRACT

Given the ongoing digitalization in modern education worldwide, it is important to determine the features of the development of digital competence among future teachers. The research problem lies in the insufficient understanding of how innovative digital interventions affect the development of these competences in teacher education. The purpose of this study is to find out the impact of innovative (digital) intervention on the development of digital competence of future teachers. A mixed-method design was used, combining qualitative and quantitative approaches. A total of 186 students of pedagogical specializations participated in the study. Participants were divided into two groups: experimental (n = 93), who underwent an intervention program, and control (n = 93), who studied according to the traditional program. The primary data were collected using a digital competence questionnaire (28 items), performance tasks ("Micro-lesson" and "Mini-module in LMS"), LMS analytics, and semi-structured interviews. Moreover, descriptive statistics, paired t-tests, ANCOVA controlling for pre-test indicators, and effect size calculations were used for data analysis. The results confirmed that the experimental group recorded a significant increase in digital competences in all domains (Δ = +2.1–+3.6; p < 0.001; d = 0.63–0.88). In addition, the intervention was more effective among students with a lower initial level of competencies (F(1,182) = 8.47; p < 0.01), as well as among students in pedagogical and humanitarian specialties. The findings suggest that targeted digital interventions can substantially improve the development of digital competence in future teachers.

INTRODUCTION

Active digitalization processes have influenced the transformation of the modern educational space and increased the requirements for the professional training of future teachers. Accordingly, a modern teacher must be proficient with ICT tools and incorporate them into educational strategies, ensure academic integrity, and promote inclusive teaching. In this context, developing digital competencies among students in higher education institutions is an important and even necessary condition for ensuring the quality of education in the coming years (Salas-Pilco & Yang, 2022). The relevance of this issue is heightened by the fact that the level of digital competence of future teachers has a “multiplicative” effect: it influences the digital literacy of hundreds of their future students and the overall use of technology in educational institutions.

The main research challenge is the scientific justification and empirical validation of pedagogical interventions that enhance the digital competencies of future teachers in key areas and facilitate their sustainable integration into pedagogical practice. In the scientific field, much has already been established. In particular, the conceptual apparatus of "digital competence" and its structural components have been developed. The general trends of the digital transformation of education and the prominent examples of the use of digital tools in teaching have also been discussed. The proposed study is valuable. In particular, in theoretical terms, it aims to expand accepted ideas about the structure of digital competencies for a future teacher by integrating the DigCompEdu/TPACK/ISTE provisions into a holistic model. In a practical sense, the study will propose a quasi-experimental design with pre- and post-measures in the control and experimental groups during

[1] *Corresponding author: ORCID ID: 0000-0003-2280-3210*

https://doi.org/10.46281/bjmsr.v11i1.2760

To cite this article: Kazbekovna, Z. K., Tumarbek, Z. Z., Sabyrkul, S., Kenesovna, K. G., & Aiym, Y. (2025). FORMATION OF DIGITAL COMPETENCES OF STUDENTS IN THE SYSTEM OF HIGHER PEDAGOGICAL EDUCATION. *Bangladesh Journal of Multidisciplinary Scientific Research*, *11*(1), 43-54. https://doi.org/10.46281/bjmsr.v11i1.2760

one educational module. Such an approach will not only allow recording students' subjective perceptions of their own skills, but also evaluating real actions and didactic solutions.

The study will aim to substantiate and empirically verify the effectiveness of targeted pedagogical intervention in the formation of digital competencies of students of higher pedagogical education institutions by identifying its general impact, the most progressive domains of competence, and the individual and contextual factors that modify this effect. Thus, this article will fill the gap between the declarative description of digital competencies and a proven model of their formation in future teachers.

LITERATURE REVIEW

The development of digital competencies among higher pedagogical education students is recognized in modern science as a key condition for preparing specialists who can act productively even amid the digital transformation of society. In international scientific literature, the term "digital competence" is often understood to refer to established international frameworks, such as DigCompEdu (Basantes-Andrade et al., 2022; Zhao et al., 2021a). In such conditions, it is an obvious integration of knowledge, skills, and attitudes that ensures future educators' ability to critically apply digital tools in teaching, educational content creation, assessment, and, especially, their own independent professional development. Researchers emphasize the multidimensional nature of this phenomenon: technical and methodological skills are closely intertwined, and individual communicative aspects are linked to ethical considerations (Zarubina et al., 2024; Kozhasheva et al., 2022).

Current scholars have noted that the digital competencies of future educators should be closely linked to the development of professional autonomy and specific aspects of innovative culture (Pantani et al., 2025; Trujillo-Juárez et al., 2025). It is considered that the more students use digital technologies, the more they will develop the ability to creatively adapt and independently solve available pedagogical problems in the future. Firstly, this is necessary for Kazakhstan's university system, as digital transformation has been declared a national priority (Dzhanegizova, 2024). Official programs and strategies emphasize the need to prepare competitive teachers who must possess modern information technologies, making them valuable employees in today's digital knowledge economy.

In the context of studying the Kazakh case, the issue of acquiring digital competencies is extensive due to the implementation of state digitalization programs and strategic development programs in this field, which are aimed at integrating digital technologies and artificial intelligence into the education sector (Andekina & Anartayeva, 2022; Ergasheva et al., 2025). Official programs and their active support at the highest level indicate the need to change teacher training to equip teachers to process new material, integrate into digital environments, and actively use the latest technologies to implement the educational process. At the same time, Kazakhstan has implemented separate educational initiatives aimed at improving pedagogical education and transforming it in accordance with modern requirements (Gulmira et al., 2024). For example, such educational changes were based on the importance of developing digital platforms, using programs to upskill future teachers, and effectively designing educational courses focused on developing information, communication, and digital skills (Sultan et al., 2025).

In some studies, the analysis of various competency frameworks (DigCompEdu, TPACK, and ISTE Standards for Educators) has also been emphasized. However, experimental tests of the effectiveness of targeted educational interventions specifically for students of pedagogical specialties remain insufficiently studied.

Moreover, current empirical studies conducted at universities in Kazakhstan are noteworthy (Shaimukhanova et al., 2024; Buzaubakova & Nurmanaliyeva, 2021). Researchers have confirmed that educators in the future will be aware of the importance of acquiring digital competencies (including independently), but the level of competencies obtained and their development remain quite uneven (Jakubakynov et al., 2024; Babu et al., 2025; Pande et al., 2024; Al Hunaini et al., 2025; Zhou et al., 2025; Hasan & Surjamokhey, 2022). Kurakbayeva & Xembayeva, 2025). The greatest successes have been achieved through the application of basic tools and well-known online platforms. However, the following more complex skills related to pedagogical design, the use of artificial intelligence in teaching, online work, and critical thinking about digital content are still underdeveloped (Kapasheva et al., 2024). Methodologically, most studies rely on student surveys and self-assessments – these tools somewhat limit the possibility of in-depth analysis of the effectiveness of educational innovations. Kuratova et al. (2016) highlighted the importance of using modern technologies to organize the educational process. In addition, Partsei et al. (2025) proved the effectiveness of mobile learning applications. Bilyk et al. (2025) also identified the importance of using innovations for training specialists. At the same time, existing scientific discussions have highlighted specific problems. Among them, the lack of a unified national model of digital competencies for pedagogical education should be highlighted first and foremost (Kolm et al., 2021). Another pressing challenge is the insufficient integration of digital technologies into educational programs, and the limited ability of university lecturers to use digital tools even as auxiliary mechanisms, let alone as full-fledged didactic resources (Neagu, 2022). An additional risk, as noted in a few studies, is the disparity in the levels of material and technical support for universities (Raza & Pate, 2023; Mazur et al., 2025), which also indirectly affects the quality of future education for students. Despite numerous scientific publications on the digitalization of education, there remains a lack of empirically supported models for pedagogical specialties that synthesize the didactic, psychological, and instrumental aspects of developing digital competencies (Nurtayeva et al., 2024). Most research focuses either on describing platforms and tools (e.g., LMS, interactive services) or on general approaches to integrating ICT into teaching (Temirkhanova et al., 2024; Sillat et al., 2021).

Even considering these results, despite the increased research activity, there are noticeable gaps in the current scientific field that require further investigation. Firstly, there is a lack of empirical research to assess the dynamics of digital competence development among students in pedagogical specialties throughout their studies. Also noteworthy is the lack of comprehensive studies that combine quantitative results with existing theoretical data, thereby providing a deeper analysis of educational practices. Thirdly, the issues concerning the integration of artificial intelligence into the training of future teachers, including through the lens of determining the consequences of digital interventions on students' professional identity, have not been sufficiently researched. Therefore, current directions for further research include developing localized frameworks for digital competencies that account for the specifics of Kazakhstan's educational policy and sociocultural context.

Accordingly, the purpose of the study is to substantiate and empirically verify the effectiveness of targeted pedagogical intervention in the formation of digital competencies of students of higher pedagogical education institutions in Kazakhstan. Taking into account the theoretical analysis and previous empirical results, the following hypotheses were formulated:

H_1: Targeted pedagogical intervention provides a statistically significant increase in the overall level of digital competencies of students compared to traditional learning.
H_2: The most significant growth is observed in the domains of digital competence related to content creation, communication, collaboration, and assessment using ICT.

MATERIALS AND METHODS

Research Design

The problem of developing digital competencies is multidimensional, encompassing objective indicators (levels of task performance, changes in questionnaire indices) and subjective aspects (student perceptions, barriers, motivation). Therefore, it is advisable to use a mixed approach. Based on this type, quantitative data will allow us to highlight the scale and significance of changes. In contrast, qualitative data will influence the explanation of "why" and "how" these changes occurred.

The study was designed as a quasi-experimental mixed design. This involved a combination of quantitative and qualitative methods. The quantitative part is based on a pre-post testing scheme with two groups: the experimental group (EG) - students undergoing a targeted pedagogical intervention to develop digital competencies; and the control group (CG) - students studying according to a traditional program without a specifically developed digital component. This design enabled assessment of the intervention's effectiveness by comparing changes in digital competence levels across groups.

Participant Characteristics and Sampling Procedures

Full-time students of pedagogical specialties of a higher education institution were involved in the study. The planned sample size is N = 186 people.

The primary selection method is cluster selection based on already formed academic groups (intact classes), with subsequent unguided distribution of groups across the research conditions. To reduce systematic differences between conditions, comparative alignment is used; in particular, pairs of academic groups with similar characteristics (course, specialty, grade point average, previous ICT experience) were selected.

Accordingly, the following students participated in the study
Experimental group (EG): n=93 students (underwent a targeted intervention to develop digital competencies)
Control group (CG): n=93 students (studied according to the usual program without a specially organized digital component.

In the case of unequal clusters, a slight asymmetry (up to ±10%) was allowed and will be taken into account during analysis.

The sample was formed according to the main criteria and was purposive. The main inclusion criteria were studying in the 2nd–4th year of a pedagogical specialty, participation in an educational module in which the intervention could be implemented, and written consent to participate.

Exclusion criteria were incomplete completion of key stages (absence at pre- or post-measurement; >30% missed intervention classes) and refusal to process personal data/consent to participate. Table 1 presents basic data on the study participants.

Table 1. Demographic characteristics of the student sample (N = 186)

Indicator	**EG (n = 93)**	**CG (n = 93)**	**Total (N = 186)**
Gender			
– Women	68 (73.1 %)	70 (75.3 %)	138 (74.2 %)
– Men	25 (26.9 %)	23 (24.7 %)	48 (25.8 %)
Age (years)			
– 18–19	28 (30.1 %)	30 (32.3 %)	58 (31.2 %)
– 20–21	45 (48.4 %)	43 (46.2 %)	88 (47.3 %)
– 22 and over	20 (21.5 %)	20 (21.5 %)	40 (21.5 %)
Course of study			
– 2nd year	32 (34.4 %)	30 (32.3 %)	62 (33.3 %)
– 3rd year	34 (36.6 %)	36 (38.7 %)	70 (37.6 %)
– 4th year	27 (29.0 %)	27 (29.0 %)	54 (29.0 %)
Specialty			

– Primary education	30 (32.3 %)	31 (33.3 %)	61 (32.8 %)
– Preschool education	22 (23.7 %)	21 (22.6 %)	43 (23.1 %)
– Secondary education (mathematics)	20 (21.5 %)	19 (20.4 %)	39 (21.0 %)
– Secondary education (philology)	21 (22.6 %)	22 (23.7 %)	43 (23.1 %)

Note. EG = Experimental Group; CG = Control Group. Percentages are calculated within each group.
Source: Author's development

Experimental Manipulations or Interventions

The intervention was carried out during one training module (12 weeks) within the framework of pedagogical disciplines. The lesson was conducted in the format of classroom meetings + online activities in the LMS.

The program provided for the active, consistent development of digital competencies across the key domains of the DigCompEdu and TPACK frameworks. In particular, in week 1, students were introduced to the program's purpose and objectives. At this stage, a diagnosis of the initial level of digital competencies (pre-test) was carried out, and the LMS was introduced.

The Planning of Training Sessions Using ICT was also Carried Out

At the next stage (week 4-5), interactive platforms (Padlet, Mentimeter, Google Docs) were actively used, and group work and peer-to-peer learning in an online environment were organized.

At week 6-7, digital content was created. This stage involved developing interactive presentations, educational videos, and microcourses. Also at this stage, various tools for visualization and multimedia support were used.

In weeks 8-9, online tests were designed, formative assessment was applied, and LMS analytics were used.

Weeks 10-11 focused on ethics and security. In particular, familiarity with confidentiality and data protection was established.

The final stage (week 12) involved completing a practical task: forming and presenting a mini-lesson using digital technologies.

At this stage, post-testing was also provided, and focus groups were held to collect qualitative data (reflection, barriers, suggestions) (See Table 2).

Table 2. Intervention plan for the formation of students' digital competencies

Week	Module content	Tools and forms of work	Competency domain (DigCompEdu/TPACK)	Expected results
1	Introduction. Diagnostics of the level of digital competencies	Pre-test (online questionnaire Google Forms/SurveyMonkey); introductory lecture; LMS (Moodle/Google Classroom) instruction	Professional engagement / Knowledge of context	Awareness of goals; orientation in LMS; determination of starting level
2–3	Information literacy and digital pedagogy	Resource search workshop (Google Scholar, ERIC, ResearchGate); working with Zotero/Mendeley; LMS lesson planning	Information & data literacy / Content knowledge + Pedagogical knowledge	Ability to find, critically evaluate sources; integrate resources into curricula
4–5	Communication and collaboration	Using Padlet, Mentimeter, Google Docs/Slides, LMS online forums, and peer-reviewed group assignments	Digital communication & collaboration / PCK	Online interaction skills, organization of teamwork, and development of critical thinking
6–7	Digital content creation	Canva, Powtoon, Genially, Loom, Edpuzzle; creating interactive presentations and educational videos	Digital content creation / Technological pedagogical knowledge (TPK)	Development of skills to develop multimedia materials and interactive courses
8–9	Assessment and feedback	Kahoot, Quizizz, Google Forms, LMS analytics; formative assessment; online rubrics	Assessment & feedback / TPK + PCK	Ability to use digital tools for assessment; skills to work with analytics
10–11	Ethics, safety, inclusion	Discussions; case analysis; Creative Commons search; introduction to GDPR/data protection; UDL (Universal Design for Learning) principles	Digital responsibility / PK + CK	Awareness of copyright issues, confidentiality, and the development of a culture of inclusion
12	Summary: integrated mini-lesson	Presentation of the developed lesson using digital technologies; post-test; focus groups	Integrated digital competence / Technological pedagogical content knowledge (TPACK)	Demonstration of comprehensive digital competencies; reflection and self-assessment

Note. LMS – Learning Management System; PCK – Pedagogical Content Knowledge; TPK – Technological Pedagogical Knowledge; TPACK – Technological Pedagogical Content Knowledge; UDL – Universal Design for Learning; GDPR – General Data Protection Regulation.
Source: Author's development

Instruments and Measures

Data collection tools that combined quantitative and qualitative methods were used. In particular, a self-assessment questionnaire for digital competencies was used, based on the DigCompEdu and TPACK frameworks. It contained blocks of questions reflecting six key domains of digital competencies: information literacy, digital pedagogy, communication and collaboration, digital content creation, ethics and security, and assessment using ICT. The questionnaire also had a scaled structure (1-5), which made it possible to obtain an integral index of digital competencies (See Appendix A). To overcome the limitations of self-reported data, the study used a range of practical tasks. The first of them was a "Micro-lesson using digital technologies", within which students prepared and delivered short lessons integrating digital tools (See Appendix B). The next task involved the formation of a "Mini-module in the LMS" (See Appendix C). This consisted of creating a learning segment using electronic resources, interactive tasks, and an assessment system. Both tasks were determined by developed rubrics with clear criteria (pedagogical expediency, interactivity, assessment and feedback, inclusiveness). This allowed us to record the real level of mastery of digital tools in pedagogical activity.

An additional source of data was the consideration of logs and analytics of the learning management system (LMS). This made it possible to obtain objective indicators of engagement: the number of entries, task completion, participation in discussions, and the timeliness of work submissions.

To expand understanding of the features of competency development, semi-structured interviews were conducted in focus groups with students in the experimental group (See Appendix D).

Reliability and Validity

The quality of the instruments was assessed against several parameters: the internal consistency of the questionnaire (Cronbach's α) and the inter-rater consistency in the assessment of practical tasks. The questionnaire (I1) demonstrated an acceptable level of internal consistency: Cronbach's $\alpha = 0.81$ for the integral scale and 0.68-0.76 for the individual domains.

For the "Micro-lesson" (I2) assessment rubric during the double assessment, the inter-rater consistency coefficient, Cohen's κ, was 0.72.

Similarly, for the task "Mini-module in the LMS" (I3), the consistency coefficient of expert assessments was ICC = 0.79. These indicators indicated reliability.

The definition of LMS analytics (I5) did not require a traditional reliability assessment; however, the technical stability of the logs, which ensures the reproducibility of the indicators, was checked.

Data Analysis

Data analysis was carried out using both quantitative and qualitative methods. However, at the initial stage, the data set was checked for completeness and correctness. Multiple imputation was used to handle missing values (less than 10%). This, in turn, enabled the sample to remain representative. The distribution of variables was previously checked, and possible outliers were identified.

Descriptive statistics were used to assess the intervention's effectiveness. In particular, mean values, standard deviations, medians, quartiles, and confidence intervals were calculated for the leading indicators (digital competence indices, performance task results, LMS data).

Within the groups (experimental/control), paired t-tests (or the nonparametric equivalent, the Wilcoxon Signed Rank Test) were performed to compare pre- and post-results.

Intergroup differences were analyzed using ANCOVA, with the post-indicator as the dependent variable and the pre-level as the covariate. Cohen's d was also calculated for pairwise comparisons. A correlation analysis was performed, including a validity check of the questionnaire results and performance task scores (Pearson's r and Spearman's r). The focus group interviews were analyzed using thematic analysis. This included transcribing the recordings, initial familiarization with the data, and open coding of participants' statements. The next stage was grouping codes into categories corresponding to barriers and facilitators of digital competence development.

To ensure the reliability of the qualitative analysis, two independent researchers coded 20% of the corpus, and consistency was checked using Cohen's κ (≥ 0.70).

RESULTS

The targeted intervention led to higher student performance than traditional teaching. At the pre-test stage, no statistically significant differences ($p > 0.05$) were found between the control (M = 45.3; 95% CI [43.9–46.7]) and experimental groups (M = 46.1; 95% CI [44.6–47.6]). This indicated their initial equivalence.

After the intervention, the mean score in the experimental group increased significantly (M = 62.9; 95% CI [61.5–64.3]), while the increase in the control group was minimal (M = 50.4; 95% CI [48.9–51.9]). Between-group analysis using ANCOVA confirmed a statistically significant difference in favor of the experimental group, $F(1,183) = 27.60$, $p < 0.001$, partial $\eta^2 = 0.18$. The effect size was large (Cohen's d = 0.82), indicating a substantial practical impact of the intervention

Table 3. Integral level of digital competencies (EG and CG)

Group	Pre-test (M ± SD, 95% CI)	Post-test (M ± SD, 95% CI)	Δ	F (ANCOVA)	p	partial η² (effect)	Cohen's d
CG (n = 93)	45.3 ± 6.9 (43.9–46.7)	50.4 ± 7.0 (48.9–51.9)	+5.1	1.82	> 0.05	0.02 (small)	0.22
EG (n = 93)	46.1 ± 7.1 (44.6–47.6)	62.9 ± 6.4 (61.5–64.3)	+16.8	27.60	< 0.001	0.18 (large)	0.82

Note. CG – Control Group; EG – Experimental Group; M – Mean; SD – Standard Deviation; CI - Confidence Interval; Δ – Mean difference between pre- and post-test; F(df) – ANCOVA test statistic with degrees of freedom; η² – Partial eta squared (effect size); Cohen's d - standardized mean difference.
Source. The author's calculations are based on the results of the experimental study.

The intervention had a differentiated impact. The most significant increase was recorded in the areas of digital content creation ($\Delta = +3.6$; $t(92) = 10.03$; $p < 0.001$; $\eta^2 = 0.21$), assessment using ICT ($\Delta = +3.4$; $t(92) = 9.77$; $p < 0.001$; $\eta^2 = 0.20$) and digital pedagogy ($\Delta = +3.2$; $t(92) = 9.21$; $p < 0.001$; $\eta^2 = 0.19$). This determined that the practical tasks that required active integration of digital technologies into the pedagogical process affected students' skill development.

Moderate growth was recorded in the domains of communication and collaboration (Δ = +2.9; $t(92) = 8.88$; $p < 0.001$; $\eta^2 = 0.17$) and information literacy (Δ = +2.7; $t(92) = 8.45$; $p < 0.001$; $\eta^2 = 0.16$). The smallest, although statistically significant, increase occurred in the area of ethics and safety (Δ = +2.1; $t(92) = 6.12$; $p < 0.01$; $\eta^2 = 0.12$). This can be explained by the relatively high starting level of students in this area.

Table 4. Dynamics of digital competencies by domain (EG)

Domain	Pre-test (M ± SD)	Post-test (M ± SD)	Δ	t(df) / F(df)	p	η² (effect)	Cohen's d
Information Literacy	3.1 ± 0.7	5.8 ± 0.6	+2.7	t(92)=8.45	<0.001	0.16	0.74
Digital Pedagogy	2.9 ± 0.8	6.1 ± 0.7	+3.2	t(92)=9.21	<0.001	0.19	0.81
Communication and Collaboration	3.2 ± 0.6	6.1 ± 0.7	+2.9	t(92)=8.88	<0.001	0.17	0.78
Content Creation	2.8 ± 0.9	6.4 ± 0.6	+3.6	t(92)=10.03	<0.001	0.21	0.88
Ethics and Security	3.7 ± 0.7	5.8 ± 0.6	+2.1	t(92)=6.12	<0.01	0.12	0.63
ICT Assessment	2.9 ± 0.8	6.3 ± 0.7	+3.4	t(92)=9.77	<0.001	0.20	0.85

Note. M – Mean; SD – Standard Deviation; Δ – mean difference between pre-test and post-test; t(df) – Student's t-test statistic with degrees of freedom; p – significance level; η² – partial eta squared (effect size); Cohen's d – standardized mean difference.

Source. The author's calculations are based on the results of the experimental study.

However, the intervention's effectiveness depended on several individual and contextual factors. In particular, the initial level of digital skills significantly influenced the intervention's effect. Students with lower basic competencies demonstrated a greater increase in the integral index (Δ = +19.2) compared to those with a higher starting level (Δ = +12.4). The interaction "group × pre-test" was significant ($F(1,182) = 8.47$, $p < 0.01$, partial $\eta^2 = 0.07$). Thus, this indicated that the lower the initial level, the greater the intervention's impact.

Secondly, the specialty of training had a specific modifying effect. The most significant increase was observed among students of pedagogical and humanitarian specialties (Δ = +17.8; Cohen's d = 0.85), while the increase was more moderate among students of technical specialties (Δ = +13.1; Cohen's d = 0.64). This is because the level of digital skills in technical subjects was already relatively high, and the potential for improvement was limited.

Third, the course characteristics also mattered. In those groups where the instructor actively integrated digital tools into practical tasks (e.g., working with the LMS, digital assessment, collaborative projects), the intervention effect was significantly more potent ($p < 0.001$; $\eta^2 = 0.09$) (See Table 5).

Table 5. Modification of the intervention effect by individual and contextual factors

Factor	Category	Pre-test (M ± SD)	Post-test (M ± SD)	Δ	F (ANCOVA)	p	partial η² (effect)	Cohen's d
Baseline Level	Low (bottom 50%)	42.1 ± 5.8	61.3 ± 6.1	+19.2	8.47	< 0.01	0.07	0.91
	High (top 50%)	49.7 ± 6.4	62.1 ± 6.7	+12.4				0.66
Specialty	Education/Humanities	45.0 ± 6.7	62.8 ± 6.2	+17.8	6.92	< 0.01	0.06	0.85
	Technical	47.2 ± 7.1	60.3 ± 6.5	+13.1				0.64
Course features	High digital integration	45.7 ± 6.9	64.0 ± 6.0	+18.3	11.24	< 0.001	0.09	0.89
	Low digital integration	46.0 ± 6.8	58.9 ± 6.6	+12.9				0.61

Note. M = mean; SD = standard deviation; Δ = mean gain (post-test − pre-test). F values are from ANCOVA models controlling for pre-test scores. Degrees of freedom were $F(1,182)$ for baseline level, F(1,181) for specialty, and F(1,180) for course features. Partial η² indicates effect size.

The diagram in Figure 1 illustrates the average increase (Δ) in students' digital competences, considering both individual and contextual factors. The most significant changes were recorded among students with lower initial levels, those studying in pedagogical and humanitarian specialties.

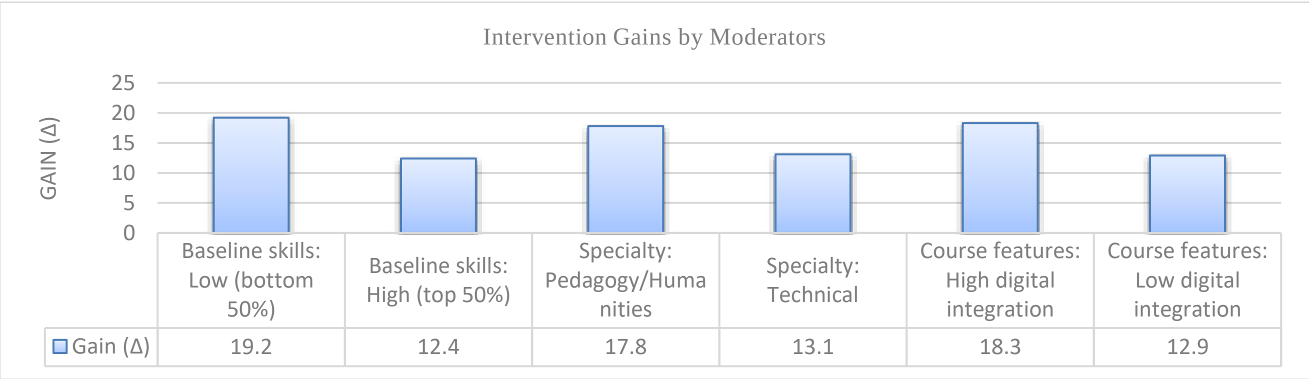

Figure 1. Intervention gains by moderators

Figure 2 shows the standardized effect sizes (Cohen's d) for different moderator categories. Moderate effects were observed among students with a higher initial level, among representatives of technical specialties, and in courses with a smaller digital component. Thus, the effectiveness of the intervention depends mainly on individual and contextual factors.

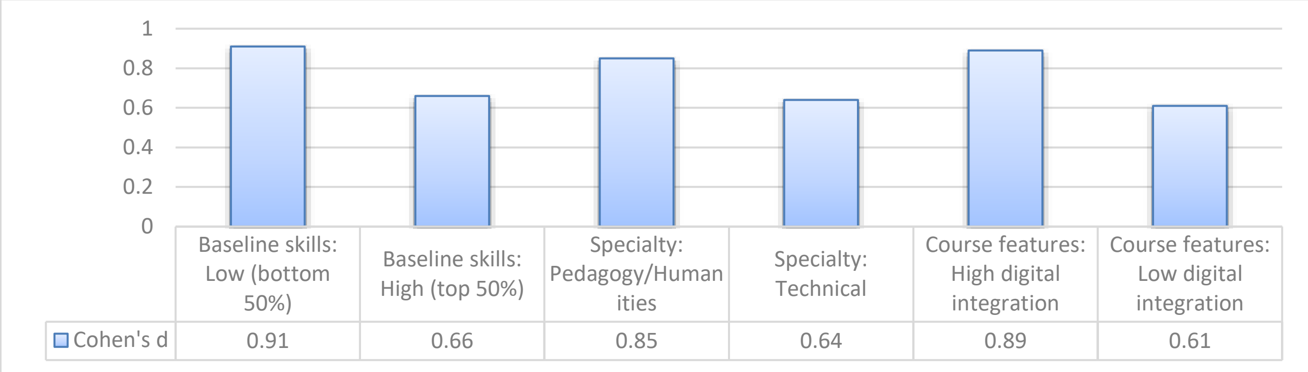

Figure 2. Standardized effect sizes (Cohen's d) for different categories of moderators

The interviews conducted covered several individual and organizational-contextual factors that influenced the targeted intervention and explained the observed variability in results. The identified factors were interpreted in two dimensions: implementation barriers and facilitators (facilitating factors). Accordingly, the main barriers were technical issues (an unstable Internet connection, insufficient equipment, and software). An important drawback was students' low digital confidence and minimal prior experience. This, in turn, affected the difficulty of completing practical tasks at the initial stages. Cognitive overload was also noticeable, arising from the intensive introduction of new digital tools. This factor partially explained the intra-group variability in results, especially in the experimental group. At the same time, the key facilitators focus on pedagogical support and feedback. Collaborative learning strategies, including working together on "mini-modules in the LMS," were instrumental in facilitating peer learning and reducing the impact of individual barriers. The practical relevance of the tasks, which were directly related to future professional activities, also had a noticeable effect.

DISCUSSIONS

The results empirically confirmed both hypotheses. The first hypothesis (H_1), that the targeted pedagogical intervention led to a statistically significant increase in students' overall digital competence compared to traditional learning, was fully confirmed. After completing the program, the experimental group showed an increase in average indicators of digital competence, indicating the effectiveness of the implemented modules and the integration of digital practices into the educational process. The results of this study showed the importance of creating a high-quality, innovative environment for the formation of digital competence of future teachers. Moreover, the results obtained demonstrated that the integrated intervention had a significant effect: the increase in the experimental group ($\Delta = +16.8$) was significantly higher than in the control group ($\Delta = +5.1$), with ANCOVA confirming a statistically significant difference ($F(1,183) = 27.6$; $p < 0.001$; $\eta^2 = 0.18$). The effect size (Cohen's $d = 0.82$) falls within the extensive range, indicating the practical significance of the intervention.

The second hypothesis (H_2), which predicted the most significant growth in the domains of digital competence related to content creation, communication, collaboration, and assessment using ICT, was also confirmed. The highest increases in indicators were observed precisely in areas focused on practical activities and interaction, which can be explained by the combination of blended learning tools (LMS, interactive services, video presentations) and elements of joint project work. Such data are consistent with studies confirming the effectiveness of practice-oriented methods of forming digital skills (integration of micro-lessons with digital tools, creation of training modules in LMS) (Timotheou et al., 2022; Suleimenova et al., 2023). Such approaches allow moving from declarative knowledge to functional mastery of digital resources. Within DigComp, the results indicate a transition of students from the "basic" to the "intermediate" and partially "higher" level of mastery. In particular, the European Digital Competence Framework has systematically identified five areas of digital skills: information and data work, communication and collaboration, digital content creation, security, and problem solving (Egusquiza et al., 2023; Inamorato dos Santos et al., 2023). It included 21 competence descriptors and four levels of mastery: from basic to expert. The specified framework has become the basis for national strategies and educational standards in many EU countries and is used by international organizations and leading technology companies (Microsoft, Intel) (Gallego Joya et al., 2025; Zhao et al., 2021b). In this sense, the study's results need to be interpreted in the context of local and international training tasks for future teachers.

The analysis showed that the most potent effects were observed in digital content creation ($\Delta = +3.6$; $d = 0.88$), ICT-based assessment ($\Delta = +3.4$; $d = 0.85$), and digital pedagogy ($\Delta = +3.2$; $d = 0.81$). This is consistent with the intervention's methodological design, which involved students completing tasks directly related to these domains: developing a "micro-lesson" and creating a "mini-module" in the LMS. More minor, but still significant, increases were recorded in the domains of information literacy (+2.7) and communication and collaboration (+2.9). The smallest increase was observed in ethics and safety (+2.1), which is explained by the relatively high starting level of students. This picture is consistent with other studies, which indicate that ethical and safety aspects are more stable and form earlier (Ospanova et al., 2025; Sitaridis & Kitsios, 2023). Other works suggest that technologies offer new opportunities to improve the quality of teaching, learning, research, and organizational management (Spante et al., 2018; Kurmanov et al., 2024). Investing in the digital skills of teachers and students brings individual and organizational benefits (González-Pérez, & Ramírez-

Montoya, 2022), in particular, the formation of quality education in innovative forms that meet the expectations and needs of students, and improved employability (Medeshova et al., 2025; Seitaliyeva et al., 2025).

In particular, it is worth considering the initial level. Students with lower basic digital skills showed greater gains ($\Delta = +19.2$; $d = 0.91$) than those with higher starting scores ($\Delta = +12.4$; $d = 0.66$). This is consistent with the results of other authors, who indicated that the intervention is particularly effective for those who experience initial deficits—the fourth question concerned barriers and facilitators to implementing digital practices. Qualitative analysis revealed several key barriers: technical limitations (unstable internet, insufficient material and technical base), low digital confidence of students, as well as cognitive overload. This is also consistent with other scholars (Mo'minova, 2024; Jedrinović et al., 2024). In particular, the scientific literature indicates that the implementation of the processes of training students in digital competencies is based on the following principles: devices and conditions, goals and possibilities of their use in the educational process, the availability of educational materials, the availability of teachers capable of radically changing teaching methods and technologies in order to provide students with the appropriate digital competencies (Fernández-Batanero et al., 2022). It is worth agreeing with the view that only the availability of digital technologies will create new opportunities for the development of human capital and the emergence of innovative "digital" industries across all areas of the economy and business (López-Nuñez et al., 2024). This means that after receiving higher education, future teachers must be able to use the digital competencies they have acquired to search for, access, analyze, and use information, as well as exchange data to fulfill their professional duties. Taking into account the data obtained and the results of other authors, the following criteria can be distinguished for determining the best service: 1. Multifunctionality. The presence of several functions in a digital tool. 2. Unification. A clear set of tools and rules, accessible and straightforward navigation. 3. Locality and confidentiality (Aubakirova et al., 2023; González Calleros et al., 2022). Team collaboration should be in a local network, and it does not mean that all information is generally available.

It is also worth considering the study's scope. In particular, the key source of information was the self-assessment questionnaire for digital competencies, developed based on the DigCompEdu and TPACK frameworks. Despite a satisfactory level of reliability (Cronbach's $\alpha = 0.81$), self-assessment always carries the risk of subjectivity and social desirability bias. This effect should be taken into account when reviewing the results. The duration of the intervention should also be considered. The intervention was carried out over a single academic semester, which does not allow for conclusions about the long-term stability of the acquired competencies. Further studies should involve a diverse sample and conduct long-term interventions.

CONCLUSIONS

The paper demonstrated the effectiveness of a targeted pedagogical intervention to develop students' digital competencies. The results showed that the EG achieved a significant, practically important increase in the integral index of digital competencies compared with the control group. The most significant growth was observed in areas related to practical pedagogical activities - digital content creation, digital pedagogy, and assessment using ICT. The study also identified several individual and contextual factors (initial skill level, specialty, and course features) that influenced the development of this competency. The results obtained are of great importance for educational practice and policy. First, the development of students' digital competencies requires the systematic integration of digital technologies into the educational process, rather than their use as an auxiliary tool. Second, teachers play a key role in overcoming barriers: their methodological support and feedback significantly enhance the effectiveness of digital interventions. Third, the most significant effect is achieved among students with a lower starting level, so educational programs should take into account individual learning trajectories. Despite the significant results, the study has several limitations. In particular, the use of a self-assessment questionnaire did not eliminate the risk of subjectivity. The intervention lasted only one semester, which does not allow for assessing the long-term stability of the results. Further research should focus on expanding the sample and extending the experiment duration. It is also worth monitoring the impact of digital interventions over time (1–2 years) to assess their stability and the transfer of results into professional activities.

Author Contributions: Conceptualization, Z.K.K. and Z.Z.T.; Methodology, Z.K.K. and S.S.; Software, Z.K.K. and K.G.K.; Validation, Z.K.K., Z.Z.T. and Y.A.; Formal Analysis, Z.K.K, Y.A. and S.S.; Investigation, Z.K.K, Y.A.; Resources, .K.K., Z.Z.T. and Y.A; Data Curation, Z.K.K. and K.G.K.; Writing – Original Draft Preparation, Z.K.K. and K.G.K.; Writing – Review & Editing, K.K., Z.Z.T. and Y.A.; Visualization, Z.K.K. and S.S.; Supervision, Z.Z.T; Project Administration, Z.Z.T.; Funding Acquisition, Y.A. Authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Ethical review and approval were waived for this study because the research does not involve vulnerable groups or sensitive issues.

Funding: The authors received no direct funding for this research.

Acknowledgments: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Andekina, R., & Anartayeva, A. (2022). Problems and Perspectives of ICT in Higher Education Institutions of Kazakhstan. In *2022 International Conference on Smart Information Systems and Technologies (SIST)*. IEEE. https://doi.org/10.1109/sist54437.2022.9945732

Aubakirova, S., Kozhamzharova, M., Zhumabekova, G., Artykbayeva, G., Iskakova, Z., & Zhayabayeva, R. (2023). Experience in forming entrepreneurial education in Kazakhstan universities in the conditions of information and digital development. *Frontiers in Education*, *8*, 1199392. https://doi.org/10.3389/feduc.2023.1199392

Al Hunaini, H. A., Al Hajri, R. M., & Chinnathambi, K. (2025). OMANI STUDENTS' PERCEPTIONS OF THE IMPACT OF PRIVATE TUTORING ON ACADEMIC PERFORMANCE. *Bangladesh Journal of Multidisciplinary Scientific Research*, *11*(1), 35-42. https://doi.org/10.46281/bjmsr.v11i1.2752

Basantes-Andrade, A., Casillas-Martín, S., Cabezas-González, M., Naranjo-Toro, M., & Guerra-Reyes, F. (2022). Standards of Teacher Digital Competence in Higher Education: A Systematic Literature Review. *Sustainability*, *14*(21), 13983. https://doi.org/10.3390/su142113983

Bilyk, L., Murzagaliev, E., Skibina, O., Hryn, O., & Kravchenko, T. (2025). Improving the practical competence of students through educational and market cooperation. *Seminars in Medical Writing and Education*, *4*, 452. https://doi.org/10.56294/mw2025452

Buzaubakova, K., & Nurmanaliyeva, U. (2021). Technological and methodological aspects of the formation of digital creative competencies of future teachers in the context of distance learning in the RK. *Journal of Educational Sciences*, *68*(3), 71–82. https://doi.org/10.26577/JES.2021.v68.i3.07

Babu, M. R. N., Atokali, Lahon, A., & Padmanaban, S. (2025). SCIENTIFIC ATTITUDE AND CRITICAL THINKING SKILLS IN SECONDARY SCHOOL STUDENTS: THE IMPACT OF GENDER AND MANAGEMENT. *Bangladesh Journal of Multidisciplinary Scientific Research*, *10*(3), 49-56. https://doi.org/10.46281/w5crnb28

Dzhanegizova, A. (2024). Digital transformation of higher education in Kazakhstan: challenges and solutions. *Economic Annals-XXI*, *209*(5-6), 42–55. Retrieved from https://www.ceeol.com/search/article-detail?id=1333430

Egusquiza, R. C., Montenegro, L. P. B., Chávez, J. A. M., Poma, A. A. R. d., Castellanos, J. A. P., Paredes, D. J. B. d., & Rivera, P. R. I. (2023). Digital Competences and Artificial Intelligence in Higher Education: Systematic Review Article. *International Journal of Membrane Science and Technology*, *10*(1), 1602–1621. https://doi.org/10.15379/ijmst.v10i1.3006

Ergasheva, G., Khursanov, R., Bazarova, D., Altiyev, R., Tadjibaeva, A., Yusupdzhanova, G., & Madatova, Z. (2025). Integrating Digital Competencies into Legal Education: A Pedagogical Framework for the Future. *Qubahan Academic Journal*, *5*(2), 446–478. https://doi.org/10.48161/qaj.v5n2a1709

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2022). Digital competences for teacher professional development. Systematic review. *European journal of teacher education*, *45*(4), 513-531. https://doi.org/10.1080/02619768.2020.1827389

Gallego Joya, L., Merchán Merchán, M. A., & López Barrera, E. A. (2025). Development and strengthening of teachers' digital competence: Systematic review. *Contemporary Educational Technology*, *17*(1), ep555. https://doi.org/10.30935/cedtech/15744

González Calleros, C. B., Guerrero García, J., Navarro Rangel, Y., González Calleros, J. M., & Collazos Ordoñez, C. A. (2022). Digital Competencies of Higher Education Institutions in Mexico: A Systematic Literature Review. In *Digital Literacy for Teachers* (pp. 313–343). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-1738-7_17

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability*, *14*(3), 1493. https://doi.org/10.3390/su14031493

Gulmira, B., Gulmira, M., Assel, O., Aigerim, O., Altanbek, Z., & Beibarys, S. (2024). Aspects of Digital Transformation of Higher Education in the Republic of Kazakhstan. In *Computational Science and Its Applications – ICCSA 2024 Workshops* (pp. 111–123). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-65282-0_7

Hasan, M. M., & Surjamokhey, S. Y. (2022). STUDENTS' DROPOUT AT THE SECONDARY LEVEL OF EDUCATION IN BANGLADESH: A CASE STUDY OF NAWABGANJ GOVT. PILOT HIGH SCHOOL & COLLEGE AT KALAKOPA UNION OF NAWABGANJ UPAZILA. *Bangladesh Journal of Multidisciplinary Scientific Research*, *6*(1), 24-29. https://doi.org/10.46281/bjmsr.v6i1.1884

Inamorato dos Santos, A., Chinkes, E., Carvalho, M. A. G., Solórzano, C. M. V., & Marroni, L. S. (2023). The digital competence of academics in higher education: is the glass half empty or half full? *International Journal of Educational Technology in Higher Education*, *20*, 9. https://doi.org/10.1186/s41239-022-00376-0

Jakubakynov, B., Tolegenuly, N., Naribai, R., Nurzhanova, Z., Shcherban, T., & Nebelenchuk, I. (2024). Innovative technologies in higher education: developing international cooperation in professional training. *Globalisation, Societies and Education*, 1–14. https://doi.org/10.1080/14767724.2024.2339309

Jedrinović, S., Kern Nanut, E., Škraba, E., & Bevčič, M. (2024). Development of online courses for the innovative use of ICT in the pedagogical process in relation to the digital competence framework for educators. In *16th international conference on education and new learning technologies*. IATED. https://doi.org/10.21125/edulearn.2024.0999

Kozhasheva, G., Maltekbassov, M., Baidildinov, T., Sakhipov, A., & Gavrilova, Y. (2022). Distance learning technologies with blockchain elements in the system of continuous education. *Cypriot Journal of Educational Sciences*, *17*(9), 3277–3288. https://doi.org/10.18844/cjes.v17i9.7474

Kurakbayeva, A., & Xembayeva, S. (2025). Enhancing professional abilities of university students through digital educational interventions: a study in Kazakhstani universities. *Frontiers in Education*, *9*, 1478622.

Kuratova, O., Zeyadauly, B., Jeldybayeva, R., Tursynali, Z., & Shynarbekova, Z. (2016). Scientific and methodological maintenance of advisor's activity as a basis of the corporate culture of the future teachers of foreign languages. *The Social Sciences (Pakistan)*, *11*(5), 710–718.

Kurmanov, N., Bakirbekova, A., & Adilbekuly, M. (2024). The Manager's Digital Competencies in Education System: A Systematic Review. *ECONOMIC Series of the Bulletin of the LN Gumilyov ENU*, (2), 141–157. https://doi.org/10.32523/2789-4320-2024-2-141-157

Kapasheva, Z., Mirza, N., Shastsitka, I., Gelmanova, Z., Makouchyk, A., & Umbetova, A. (2024). Modeling the development of pedagogical competence in higher education educators amid the digitization of the contemporary world. *Frontiers in Education*, *9*, 1360712. https://doi.org/10.3389/feduc.2024.1360712

Kolm, A., de Nooijer, J., Vanherle, K., Werkman, A., Wewerka-Kreimel, D., Rachman-Elbaum, S., & van Merriënboer, J. J. G. (2021). International Online Collaboration Competencies in Higher Education Students: A Systematic Review. *Journal of Studies in International Education*, *26*(2), 183-201. https://doi.org/10.1177/10283153211016272

López-Nuñez, J.-A., Alonso-García, S., Berral-Ortiz, B., & Victoria-Maldonado, J.-J. (2024). A Systematic Review of Digital Competence Evaluation in Higher Education. *Education Sciences*, *14*(11), 1181. https://doi.org/10.3390/educsci14111181

Mazur, H., Bolhov, V., Akhnovska, I., Dluhopolskyi, O., & Kozlovskyi, S. (2025). The impact of educational development on the countries' competitiveness in the knowledge economy. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, (1), 140–146. https://doi.org/10.33271/nvngu/2025-1/140

Medeshova, A., Adelbaeva, N., Kushekkaliev, A., Akimova, S., Khazhgaliyeva, G., Ramazanova, L., & Kassymova, A. (2025). The Impact of Pedagogical Approaches for Forming Digital Competence in Students. *Qubahan Academic Journal*, *4*(4), 374–382. https://doi.org/10.48161/qaj.v4n4a1023

Mo'minova, M. M. (2024). Developing digital media competence in future teachers in a digital educational environment. *Multidisciplinary Journal of Science and Technology*, *4*(12), 824–827. https://doi.org/10.5281/zenodo.14552081

Neagu, G. (2022). Understanding the Implications of Digital Competence for the Education Process in Romania. A Literature Review. In *Digital Literacy for Teachers* (pp. 441–462). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-1738-7_21

Nurtayeva, D., Kredina, A., Kireyeva, A., Satybaldin, A., & Ainakul, N. (2024). The role of digital technologies in higher education institutions: The case of Kazakhstan. *Problems and Perspectives in Management*, *22*(1), 562–577. https://doi.org/10.21511/ppm.22(1).2024.45

Ospanova, A., Mukhametzhan, A., Nurbayev, Z., Mukanov, M., & Baigabylov, N. (2025). Strategic reflections on digital transformation, scientific literacy, and labor market development in the Eurasian Economic Union: Insights from the case of Kazakhstan. *Iberoamerican Journal of Science Measurement and Communication*, *5*(3), 1–13. https://doi.org/10.47909/ijsmc.256

Pande, S., Moon, J. S., & Haque, M. F. (2024). EDUCATION IN THE ERA OF ARTIFICIAL INTELLIGENCE: AN EVIDENCE FROM DHAKA INTERNATIONAL UNIVERSITY (DIU). *Bangladesh Journal of Multidisciplinary Scientific Research*, *9*(1), 7-14. https://doi.org/10.46281/bjmsr.v9i1.2186

Pantani, K., Lettow, N., & Littkemann, J. (2025). Digital Examinations in Higher Education - A Systematic Literature Review. *International Journal of Communication, Science and Technology*, *1*(2), 41–74.

Partsei, K., Shevchuk, B., Buksar, S., Kurtyak, F., & Barabanchyk, O. (2025). The impact of using mobile apps on student engagement and involvement in the learning process. *Periodicals of Engineering and Natural Sciences (PEN)*, *13*(1), 219–232. https://doi.org/10.21533/pen.v13.i1.248

Raza, M., & Pate, A. (2023). Digital Professional Competence (DProCom) for Higher Education: A Systematic Review of Literature. *Qlantic Journal of Social Sciences and Humanities*, *4*(4), 385–392. https://doi.org/10.55737/qjssh.532019821

Salas-Pilco, S. Z., & Yang, Y. (2022). Artificial intelligence applications in Latin American higher education: a systematic review. *International Journal of Educational Technology in Higher Education*, *19*, 21. https://doi.org/10.1186/s41239-022-00326-w

Seitaliyeva, A., Shyndaliyev, N., Altynbekova, Z., Yermanova, G., & Caliskan, E. (2025). Integration of digital technologies into the methodology of teacher training in the system of dual education. *Periodicals of Engineering and Natural Sciences (PEN)*, *13*(3), 695–710. https://doi.org/10.21533/pen.v13.i3.472

Shaimukhanova, Z., Dussipov, Y., Taubayev, B., Abdilda, D., & Dussebayev, T. (2024). The development of state-legal regulation and certain civil law aspects of the higher education system in the Republic of Kazakhstan. *Scientific Herald of Uzhhorod University Series Physics*, (56), 2045–2054. https://doi.org/10.54919/physics/56.2024.204dq5

Sillat, L. H., Tammets, K., & Laanpere, M. (2021). Digital Competence Assessment Methods in Higher Education: A Systematic Literature Review. *Education Sciences*, *11*(8), 402. https://doi.org/10.3390/educsci11080402

Sitaridis, I., & Kitsios, F. (2023). Digital entrepreneurship and entrepreneurship education: a review of the literature. *International Journal of Entrepreneurial Behavior & Research*, 30(2-3), 277–304. https://doi.org/10.1108/ijebr-01-2023-0053

Spante, M., Hashemi, S. S., Lundin, M., Algers, A., & Wang, S. (2018). Digital competence and digital literacy in higher education research: Systematic review of concept use. *Cogent Education*, *5*(1), 1519143. https://doi.org/10.1080/2331186x.2018.1519143

Suleimenova, Z. T., Pristupa, E. N., Babayan, A. V., Prokhorova, O. G., & Illarionova, L. P. (2023). Formation of Students' Media Culture in the Conditions of Digitalization of Education in Kazakhstan. In *ESG Management of the Development of the Green Economy in Central Asia* (pp. 385–395). Springer International Publishing. https://doi.org/10.1007/978-3-031-46525-3_41

Sultan, Y., Dautova, G., Alkebayeva, D., Akzhigitova, A., & Aden, Z. (2025). Analysis of modern strategies for using artificial intelligence technologies in the creation of fantasy content. *Digital Scholarship in the Humanities*, *40*(1), 295-307. https://doi.org/10.1093/llc/fqae090

Temirkhanova, M., Abildinova, G., & Karaca, C. (2024). Enhancing digital literacy skills among teachers for effective integration of computer science and design education: A case study at Astana International School, Kazakhstan. *Frontiers in Education*, *9*, 1408512. https://doi.org/10.3389/feduc.2024.1408512

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2022). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, 28, 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Trujillo-Juárez, S.-I., Chaparro-Sánchez, R., Morita-Alexander, A., Escudero-Nahón, A., & Delgado-González, A. (2025). Strengthening teacher digital competence in higher education through micro-courses: a systematic literature review. *Discover Education*, *4*, 247. https://doi.org/10.1007/s44217-025-00687-0

Zarubina, V., Zarubin, M., Yessenkulova, Z., Salimbayeva, R., & Satbaeva, G. (2024). Digital transformation of the promotion of educational services of Kazakhstani universities. *Journal of Innovation and Entrepreneurship*, *13*, 3. https://doi.org/10.1186/s13731-023-00355-3

Zhao, Y., Pinto Llorente, A. M., & Sánchez Gómez, M. C. (2021a). Digital competence in higher education research: A systematic literature review. *Computers & Education*, *168*, 104212. https://doi.org/10.1016/j.compedu.2021.104212

Zhou, J., Soo, H. S., & Aziz, A. B. (2025). PERSON-ORGANIZATION FIT AND JOB BURNOUT AS PREDICTORS OF QUIET QUITTING IN VOCATIONAL EDUCATION. *Bangladesh Journal of Multidisciplinary Scientific Research*, *10*(4), 30-41. https://doi.org/10.46281/c9d2ab72

Zhao, Y., Sánchez Gómez, M. C., Pinto Llorente, A. M., & Zhao, L. (2021b). Digital Competence in Higher Education: Students' Perception and Personal Factors. *Sustainability*, *13*(21), 12184. https://doi.org/10.3390/su132112184

APPENDICES

Appendix A: Student Digital Competence Questionnaire (self-assessment from 1 to 5).

Block 1. Information Literacy
I can find reliable sources for educational activities through specialized search engines.
I can evaluate the reliability and relevance of the information found.
I organize and systematize digital materials using bibliography managers or cloud services.
I teach students to check information and critically evaluate it.
Block 2. Digital Pedagogy
I plan lessons so that students work with shared online documents
I use LMS (Moodle, Google Classroom) to organize the learning process.
I combine digital and traditional teaching methods depending on the didactic goals.
I can integrate interactive online tools (Kahoot, Mentimeter) into lessons to activate students.
Block 3. Communication and Collaboration
I organize student group work in a digital environment.
I use digital tools to communicate with students outside of class.
I can create an online environment for peer-to-peer learning and peer assessment.
I maintain academic integrity in digital interaction.
Block 4. Digital Content Creation
I create my own multimedia materials (videos, interactive presentations).
I adapt digital materials to the needs of different students.
I use tools for data visualization (infographics, charts).
I can integrate the created resources into LMS learning modules.
Block 5. Assessment and Feedback
I can configure automatic assessment criteria in the LMS.
I use digital tools for formative assessment.
I use different digital methods for individual feedback.
Block 6. Ethics, safety, and inclusion
I check licenses (Creative Commons, open) before using media in the course.
I take confidentiality and the protection of personal data into account when working in an online environment.
I ensure the inclusivity of digital resources

Block 7. Integrated competencies
I can combine subject knowledge with digital technologies to create educational content.
I integrate digital tools to meet the lesson's methodological objectives.
I know how to select ICT qualitatively
I evaluate the effectiveness of applied digital technologies

Appendix B: Evaluation rubric for Micro-lesson using digital technologies

Criterion	0 points (none)	1 point (low level)	2 points (average level)	3 points (high level)
Pedagogical Appropriateness	Does not meet objectives	Partially compliant	Compliant, but superficial	Fully compliant, integrated into the lesson
Interactivity and Collaboration	None	Minimal elements	A few interactive elements	Thoughtful interactivity, effective collaboration
Assessment and Feedback	None	Insufficiently structured	Partially organized	Clear formative assessment, timely feedback
Inclusion and UDL	Not taken into account	Partially considered	Accepted, but with limitations	Fully integrated (subtitles, alternative formats)
Ethics and Safety	Ignored	Only partially complied with	Generally met	Fully compliant (CC licenses, data protection)

Maximum score: 15

Appendix C: Evaluation Rubric for the Mini-Module in the LMS

Criterion	0 points	1 point	2 points	3 points
Structure and navigation	None	Insufficient	Satisfactory	Clear, logical
Coherence of goals and objectives	None	Partial	Mainly agreed	Fully consistent
Content quality	Very low	Basic	Sufficient	High, professional
Interactivity	None	Minimal	A few elements	Systematically organized
Evaluation and analytics	None	Very limited	Basic tools used	Fully evaluated with analytics
Inclusivity (UDL)	None	Partial	Generally considered	Fully integrated
Ethics and copyright	Violated	Partially taken into account	Mostly considered	Fully complied with

Maximum score: 15

Appendix D: Guide for focus groups and interviews

Questions:
What was most useful for you in the program?
What digital tools did you start using most often?
What difficulties did you encounter when working with digital technologies?
Did you have any technical difficulties?
What factors do you consider important for the development of digital competence?
How do you assess the changes in your readiness to use ICT in future pedagogical practice?