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RESEARCH RESULTS ON THE INFORMATION AND COMMUNICATION COMPETENCIES OF FUTURE INFORMATICS TEACHERS

The article is devoted to the study of the level of information and communication competencies of future informatics teachers and the assessment of the impact of the use of interactive technologies and ICT in laboratory classes on its development. The study was attended by students of the educational programs 6B01505 – "Informatics" and 6B01502 – "Mathematics-Inforomatics" of Zhetysu University named after I.Zhansugurov and the Caspian University of Technology and Engineering named after Sh.Yessenov, who were divided into control and experimental groups. The experimental group studied using modern educational platforms and interactive tools, the control group took classes in the traditional way. The results of online surveys before and after the experiment showed a improvement in the level of ICT competence among students of the experimental group, which confirms the hypothesis about the positive impact of ICT on future teacher training. The article also provides recommendations for the further development of approaches to the digitalization of teacher education.

Keywords: ICT competence, future teacher training, digitalization of education, interactive technologies, laboratory classes, virtual technologies, pedagogical informatics.

Introduction

In modern conditions of society's development, information and communication technologies play a key role in all fields of activity. On the approval of the Concept for the development of higher education and Science in the Republic of Kazakhstan for 2023–2029 [1]: «the improvement of digital competencies of citizens will be continued through the system of training, retraining and obtaining micro qualifications in the field of ICT. Digital competencies will become a mandatory element of all professional standards». In a world where digitalization is becoming an integral part of every aspect of life, preparing future teachers for the effective use of ICT in educational practice is becoming one of the main tasks of higher education institutions.

The fourth UN goal in the field of sustainable development is to ensure inclusive and equitable quality education [2]: "by 2030, significantly increase the number of young and adult people with in-demand skills, including vocational and technical skills, for employment, decent work and entrepreneurship". The ability of future computer science teachers to apply ICT in their professional activities not only expands their professional competencies, but also improves the quality of the educational process, stimulates student interest and develops their digital skills.

The information and communication competence of future teachers is one of the most important components of their professional readiness. ICT competence is understood as a set of knowledge, skills and abilities necessary for the effective use of modern technologies in the learning process. The inclusion of ICT in the educational process allows the teacher:

– master and apply modern learning tools;

– to develop students' skills of critical thinking and independent work with information;

– interact with students using various digital platforms and tools.

The object of the research is the process of forming the ICT competence of future computer science teachers in the context of digitalization of education.

The subject of the research is the influence of interactive educational technologies (Google Classroom, Stepik, virtual laboratories) on the development of ICT competence of students of pedagogical specialties.

The purpose of the study is to identify how the use of modern ICT platforms affects the development of ICT competencies of future computer science teachers during laboratory classes.

The research was conducted within the framework of the discipline «Information and Communication Technologies».

Research methodology:

1 Questionnaire – measuring the level of ICT competence of students before and after the experiment. The questionnaire included 36 questions grouped into 6 competencies.

2 Pedagogical experiment – a comparison of the effectiveness of traditional teaching and learning using interactive technologies.

3 Statistical analysis – Mann–Whitney U-test to check the significance of differences, Cronbach's alpha to assess the reliability of the questionnaire.

The object of the research is the process of forming the ICT competence of future computer science teachers in the context of the use of interactive educational technologies.

The practical significance of the work lies in the possibility of applying the research results to develop additional training courses aimed at developing the ICT competence of future computer science teachers. This will help improve the quality of teacher training and ensure more successful implementation of ICT in the educational process.

Thus, this study is aimed at accepting or rejecting the null hypothesis.

Null hypothesis (H0): The use of interactive educational technologies in laboratory classes does not have a significant impact on the development of students' ICT competencies.

Alternative hypothesis (H1): Interactive educational technologies contribute to a significant increase in the level of ICT competencies of students through active involvement in the learning process and the use of digital tools.

The results obtained can be useful to teachers of higher educational institutions and in the development of educational programs aimed at training modern teachers with high level of ICT competencies.

Materials and methods

Gendina N. I. [3] described ICT competence as a set of information worldview and a system of knowledge and skills that ensure purposeful independent activity to optimally meet individual information needs using both traditional and new information technologies.

As noted by Reang J. and Mohalik R. [4], competence in the field of information and communication technologies consists in having sufficient knowledge of technologies and the subject area of teaching and being able to create suitable lessons based on technologies that can be used in the learning process. The existing society is innovative and creative, and the innovative environment promotes interactive learning.

In order to create an ICT-based teaching and learning environment, it is also necessary to provide ICT teacher training. Teachers should be aware of ICT and

what it can provide. They should be able to critically evaluate and distinguish which technological resource to use and whether it should be used at all. They should also be able to understand conceptually and pedagogically how, where and why to use computer technology. Thus, it is obvious that teachers need competencies to successfully use ICT in teaching. Apart from the ICT implementation strategy, there is some confusion about the ICT competencies that teachers should acquire.

According to the research of Selevko G.K. [5], ICT competence includes the following components: «Technological component, Information component, Communicative component, Creative component, Value-motivational component». Based on this work, we have identified the following skills:

1 Operational skills. Knowledge of basic ICT tools: Computer skills, software basics, and Internet technologies.

2 Information skills. Information retrieval and evaluation: The ability to effectively find, analyze, and evaluate information on the Internet for educational and research purposes.

3 Communication skills. Digital communication: Developing effective communication skills in a digital environment, including sharing data and research results through online platforms and social media.

4 Critical thinking and problem solving. Analytical thinking: Developing the ability to critically analyze information and draw informed conclusions based on data obtained during virtual experiments.

5 Project management. Project Planning and Management: Project planning, organization, and management skills, including virtual laboratory and research projects.

6 Security and ethics in ICT. Digital security: Understanding the principles of data security and protection in a digital environment.

Modern ICTs are rapidly transforming the educational process, offering new forms of interaction between teachers and students. The introduction of digital technologies into education changes both the content of the educational process and the methods of its organization. One of the key functions of ICT is to expand opportunities for personalized learning, where each student can work at a pace that suits them, using resources and materials tailored to their individual needs.

ICTs make the learning process more interactive and visual, which stimulates students' activity and increases their interest in the subject being studied. Electronic learning materials such as video tutorials, interactive presentations, simulations, and virtual labs allow for more effective explanation of complex topics and concepts. As a result, students can better understand and memorize the material.

The research of Schmidt A. Denise, Evrim Baran, Ann D. Thompson, Punya Mishra, Matthew J. Koehler, and Tae S. Shin [6] revealed that teachers who actively

use ICT demonstrate better results in teaching students, especially when they use technology to create an interactive learning environment and adapt content to the needs of students.

Laboratory work occupies a central place in the learning process of students of pedagogical informatics, as it allows them to integrate theoretical knowledge with practical skills. Laboratory classes are a form of active learning where students have the opportunity to work with real or simulated systems and processes using software, hardware, and other ICT tools.

In the context of computer science teacher training, laboratory work is especially important, as it allows future teachers to master a wide range of skills, ranging from programming and information technology to creating educational materials and resources based on ICT. This not only contributes to the development of their professional competencies, but also helps to form pedagogical readiness for the introduction of ICT in the educational process.

In the work of Anoemuah R. [7], it was noted that in the past, the cost of hardware and software limited the real impact of ICT on scientific laboratories. Recently, however, hardware costs have decreased dramatically, hardware has also become more reliable, and employees' ICT skills have improved.

Duterte's research [8] demonstrates that the integration of ICT significantly improves academic performance, with teacher readiness, student engagement, and institutional support playing a key role in these relationships. The results show that the effective use of technology in the classroom has a positive effect on student academic performance, provided that teachers are well trained and receive professional development support.

The digitalization of education has led to the emergence and active use of various interactive platforms and technologies that have radically changed the approach to organizing the educational process. Among the most popular interactive platforms are Google Classroom, Stepik, Microsoft Teams, Zoom and many others. These platforms allow teachers not only to organize distance learning, but also to provide an individual approach to each student, as well as provide a wide range of tools for monitoring academic performance and analyzing learning activities.

Interactive technologies allow the use of game methods to motivate students, which, according to research by Abiltarova E., Larysa L., Zhuravel Y., Neizhpapa L., Mengyi Y. [9], significantly increases the level of involvement and interest in learning. An important advantage of interactive technologies is also the possibility of constant feedback, which helps students to adjust their knowledge and skills in a timely manner.

Studies conducted in different countries confirm that the introduction of interactive technologies into the educational process contributes to improving academic performance, developing critical thinking and increasing motivation to learn. In particular, the research of Goodyear P. [10] showed that students who study using interactive platforms show better results compared to those who studied using traditional methods. It is also important to note that the use of interactive technologies contributes to the formation of independent work skills, which is especially important in the context of distance or hybrid learning. This allows students not only to gain knowledge, but also to develop self-organization skills, which is an important aspect in preparing for professional activity.

Methods

The following methods were used to analyze the materials and results of the study:

1 General scientific methods of theoretical research: comparative analysis of pedagogical and scientific-methodical, specialized literature on the research topic;

2 Methods of sociological research: questioning of future computer science teachers, comparison, classification, analysis of survey results;

3 Methods of empirical research: conducting a pedagogical experiment, using statistical research methods, processing and analyzing the results.

The study was conducted among first-year students of Zhetysu University and the Caspian University of Technology and Engineering, enrolled in educational programs of pedagogical informatics. The sample was formed from students of pedagogical informatics, as they have already completed basic ICT disciplines and have primary skills in working with information and communication technologies. A total of 45 students participated in the study, which were divided into two groups: control and experimental.

The control group consisted of 24 students from the Caspian University of Technology and Engineering, who continued to study according to the traditional methodology. The experimental group included 21 students from Zhetysu University who participated in educational classes using interactive platforms and the latest ICT.

Data collection

The stages of data collection and methods of their analysis are shown in Figure 1.

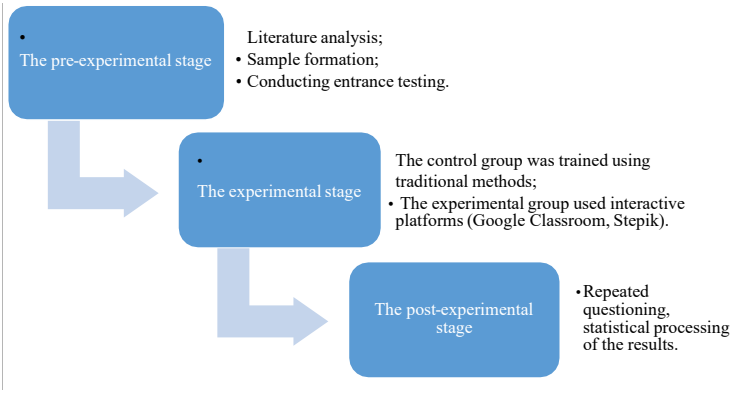

Figure 1 – Stages of research

At the initial stage of the study, an online survey was conducted among students of both groups to assess their initial level of ICT competence. The questionnaire was developed on the basis of research by Danner Regina and Clara O.A. Pessu. [11], Oghenevwede O. [12], used in pedagogical practice to assess digital skills and knowledge. The survey included 36 questions divided into six skills: Operational Skills, Information Skills, Communication Skills, Critical Thinking and Problem Solving, Project Management, Security and Ethics in ICT.

Each question was evaluated on a five-point scale, where 1 – lack of skill, 5 – high level of competence. The data obtained were processed using statistical methods to obtain an average assessment of the level of ICT competence of each of the groups at the initial stage.

The aim of the experiment was to determine how the use of interactive educational technologies and modern ICT in laboratory classes affects the development of students' ICT competence. For this purpose, the study was planned in the form of a pedagogical experiment involving control and experimental groups.

In the control group, classes were conducted in a traditional format, where teachers used standard teaching methods such as lectures, practical exercises, and basic computer science laboratory work. The training was conducted without the active use of modern interactive technologies. Laboratory classes included solving problems using basic software tools, but did not include interactive platforms and complex simulations.

A laboratory training program was developed for the experimental group with the active use of modern information and communication technologies and interactive educational platforms. As part of the laboratory classes, platforms such as Google Classroom, Stepik, artificial intelligence for Internet search Perplexity,

as well as specialized simulators and virtual laboratories for modeling software and hardware processes were used. The students worked on creating their own projects using ICT, which contributed to the development of creative and analytical abilities. The main focus was on developing independent work and research skills in a digital environment.

The program for the experimental group included:

• The use of online courses and educational videos for a preliminary introduction to the topic of laboratory work;

• Work with virtual simulators to perform practical tasks that would be impossible in a traditional form due to limitations in equipment;

• Working with AI to search the Internet and analyze the results obtained;

• Actively interact with teachers and students through educational platforms to discuss work results, complete group assignments, and provide feedback.

Based on the data obtained, it is planned to conduct an analysis that will show how different the results of the students of the two groups are from each other. It is expected that the use of modern technologies will not only improve students' technical and information skills, but also increase their motivation and involvement in the learning process.

Results and discussion

The study aimed to assess the impact of experimental intervention on the skills and knowledge of students divided into two groups: control and experimental. The students' grades were collected before and after the experiment using a five-point Likert scale, where 1 indicates the minimum skill level and 5 indicates the maximum.

The first step was to evaluate the reliability and validity of a questionnaire designed to measure the level of knowledge and skills of students in several parameters. The reliability and validity of measurement tools are important aspects to ensure the accuracy and reproducibility of the data obtained.

To assess the reliability of the questionnaire tool used, the Cronbach's Alpha coefficient was calculated [13], which allows us to determine the degree of internal consistency of questions. This indicator is used to check to what extent all the elements of the questionnaire measure the same characteristic.

The calculations were performed using Microsoft Excel. In the questionnaire table, the respondents were arranged in rows, and the questions were arranged in columns. The following steps were performed during data processing:

The variance of answers for each question of the questionnaire was calculated using the VAR.P() function.

The sum of the variances of all questions was determined.

The variance of the total amount of respondents' scores on all questions is calculated:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right) \quad (1)$$

where *k* is the number of questions in the questionnaire, $\sum \sigma_i^2$ — the sum of the variances of individual questions, a σ_t^2 — the variance of the sum of all respondents' responses.

The calculated value of the Cronbach's Alpha coefficient was 0.96, which indicates the high reliability of the questionnaire and sufficient consistency of the questions, and this allows using this tool in further statistical analyses.

The results of the assessment of the ICT competence of students in the control and experimental groups.

Diagram 1 shows the average value of the indicators for the control and experimental groups for the six skill blocks before and after the experiment. Each skill block is evaluated on a five-point scale, where higher values indicate a higher level of competence. Skill blocks include: operational skills, information skills, communication skills, critical thinking and problem solving, project management and security, and ethics in ICT.

The main conclusions:

1 Competence growth in the experimental group. After conducting classes using interactive technologies, the indicators of students' ICT competencies in the experimental group increased significantly.

2 Minimal changes in the control group. In the control group, where the training was conducted using traditional methods, the changes were insignificant. The difference between the pre- and post-experimental values is only 0.03-0.05 points, which indicates a weak impact of standard education on the development of ICT competencies.

3 Maximum growth in the category of «Security and ethics in ICT». The biggest changes occurred in this particular block – the score increased from 2.38 to 3.59 points in the experimental group, which indicates a significant increase in students' awareness of digital security issues.

4 All six competencies show positive dynamics in the experimental group, while the control group shows stable but minimal changes.

	Operational Skills	Information Skills	Communication Skill	Critical Thinking and Problem Solving	Project Management	ICT Security and Ethics
After the Experiment (Experimental Group)	3,57	3,42	3,57	3,49	3,58	3,59
After the Experiment (Control Group)	2,46	2,44	2,53	2,54	2,43	2,43
Before the Experiment (Experimental Group)	2,42	2,45	2,43	2,48	2,38	2,42
Before the Experiment (Control Group)	2,43	2,39	2,43	2,49	2,36	2,38

Diagram 1 – Results of the assessment of students' ICT competence.

The Mann-Whitney U-test was applied to verify the statistical significance of the differences in the results before and after the experiment. This nonparametric test is suitable for comparisons between two independent samples and allows you to evaluate the differences between the distributions of values. Since the data did not necessarily follow a normal distribution, the choice of the Mann-Whitney test was justified.

The following steps were performed to perform the analysis:

1 Data preparation: The assessment data for each group was divided into two samples: the values before the experiment and the values after the experiment. Thus, two data arrays corresponding to two time points were generated for each group.

2 Calculation of U-statistics and p-values: The Mann-Whitney test was performed for each group, and a two-way test was used to test for differences in

both directions. The test result includes a U-statistic and a p-value, which shows the probability of obtaining such differences randomly.

3 Calculation of the Z-value and the size effect (r): Additionally, the Z-value and the size effect (r) were calculated. The Z-value determines the standard deviation from the average value of U, which allows the results to be normalized. The effect of the size r allows you to evaluate the strength of the experiment's influence on the results.

Formulas for calculations:

1 U-criteria for each group

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2} \quad (2)$$

$$U_2 = R_2 - \frac{n_2(n_2+1)}{2} \quad (3)$$

where:

• R_1 and R_2 are the sum of the ranks for the first and second groups;

• n_1 and n_2 are the sample sizes for the first and second groups.

2 Choosing the smallest U value:

3 For comparison, the smallest of the two values U_1 and U_2 is used, as it is more sensitive to differences between groups.

4 Z-value calculation: The U-criterion was converted to a standard normal distribution using the following formula:

$$Z = \frac{U - E(U)}{\sigma(U)} \quad (4)$$

where:

• E(U) - mathematical expectation of U:

$$E(U) = \frac{n_1 \times n_2}{2} \quad (5)$$

• σ (U) - standard deviation of U:

$$\sigma(U) = \sqrt{\frac{n_1 \times n_2 \times (n_1 + n_2 + 1)}{12}} \quad (6)$$

5. Effect magnitude (r): The following formula is used to estimate the effect magnitude:

$$r = \frac{Z}{\sqrt{N}} \quad (7)$$

where:

• $N=n_1+n_2$ - total number of observations.

Mann-Whitney Test Results

The results of the analysis are presented in Table 1, which shows the values of U-statistics, p-value, Z-value and size effect (r) for the control and experimental groups. Mann-Whitney test results for the control and experimental groups before and after the experiment.

Table 1 – Mann-Whitney U-Test Results

Control group	Results	Experimental group
24	n1	21
24	n2	21
48	N	42
525.5	R1	231
650.5	R2	672
225.5	U1	0
350.5	U2	441
192	U	142
-0.48601	Effect (r)	-0.8559
48.49742	σ (U)	39.7524
288	E(U)	220.5
-1.28873	Z-value	-5.54684
0.198	p-value (0.05)	6.63×10−8
Accepted	Status	Rejected

Interpretation of results

• For the control group, the p-value was 0.198, which exceeds the standard significance level of 0.05. This indicates that there are no statistically significant differences between the estimates of the control group before and after the experiment. The low value of the size effect (r = -0.48601) also indicates a negligible effect on the group's performance.

• In the experimental group, the p-value was 6.63×10-8, which is significantly lower than the threshold level of 0.05. This indicates that there are statistically significant differences between the results before and after the experiment. The effect of size (r = -0.8559) is high, which indicates a significant effect of the experiment on the results of the group.

The results of the analysis show that the experimental intervention had a statistically significant effect on the experimental group, while there were no significant changes in the control group. This allows you to reject the null hypothesis and accept an alternative hypothesis.

Discussions

The conducted research is an important contribution to the study of the effectiveness of the use of information and communication technologies in the training of future computer science teachers. Unlike other similar studies like Avdeeva S. and Tarasov K. [14], Ratheeswari K. [15], which focus on the general assessment of digital literacy, our study focuses specifically on the pedagogical component of ICT competence, a critically important area in the context of modern educational reforms. Compared to other studies that assess the impact of ICT on students in a more general context, our work takes a detailed approach to analyzing specific components of ICT competence, such as technical, information, and creative skills, as well as their impact on teaching effectiveness. These aspects make the research especially relevant in the context of the growing digitalization of the educational process, which underlines its importance for the pedagogical community.

To assess the level of students' ICT competence, we have developed our own questionnaire adapted to the specifics of training future computer science teachers. This decision was based on the need to take into account specific pedagogical aspects that are not always reflected in standard questionnaires used in other studies such as Danner R. and Pessu C. [11], Oghenevwede O. [12].

To ensure the reliability of our survey, a reliability analysis was performed, and the Cronbach's Alpha score was 0.96, indicating a high consistency of questions. This gives us confidence that the data obtained is objective and reliable, which distinguishes our study from others, where attention is not always paid to verifying the reliability of the assessment tool.

One of the key reasons for choosing this research area is the strategic importance of digitalization of education in Kazakhstan. In recent years, the country has been actively implementing ICT implementation programs in educational institutions, and the training of qualified teachers capable of effectively using digital technologies has become a priority. According to government initiatives and strategic programs, such as the Law of the Republic of Kazakhstan on Education

dated July 27, 2007 No. 319-III, the emphasis is on training specialists with modern ICT tools to improve the quality of education [16].

The results highlight the need for further research into the use of ICT in teacher training. It is important to study the long-term effects of the use of interactive technologies on the development of professional competencies of future teachers, as well as to study which specific types of ICT have the greatest impact on students' learning outcomes. Additionally, an analysis of the impact of digital technologies on the motivation and academic performance of students of various age categories is required. Thus, our research is the basis for deeper and more detailed work in this area.

Conclusions

The results of the study confirmed that the use of interactive technologies contributes to a significant increase in students' ICT competencies (a difference of 1.3 points, $p < 0.05$). This highlights the need to integrate modern digital platforms into the educational process. This confirms the alternative hypothesis of the study on the positive impact of the use of ICT on the training of future computer science teachers.

Practical recommendations:

1 Integration of interactive technologies. It is important to include the use of platforms such as Google Classroom, Stepik and specialized simulators for laboratory classes in educational programs, which stimulates creative thinking and active participation of students.

2 Development of communication skills. The use of ICT for teamwork on projects, knowledge sharing and interaction in a digital environment contributes to the development of digital communication and teamwork skills.

3 Adaptation of educational programs. It is recommended to review the content of laboratory classes with an emphasis on the development of students' creative approach and critical thinking through digital technologies.

The prospects for further research include a more detailed study of the long-term impact of ICT on the professional development of future teachers, as well as a study of the impact of various types of interactive programs on learning outcomes in other pedagogical disciplines.

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БОЛАШАҚ ИНФОРМАТИКА МҰҒАЛІМДЕРІНІҢ АҚПАРАТТЫҚ-КОММУНИКАЦИЯЛЫҚ ҚҰЗЫРЕТТІЛІКТЕРІН ЗЕРТТЕУ НӘТИЖЕЛЕРІ

Мақала болашақ информатика мұғалімдерінің ақпараттық-коммуникациялық құзыреттіліктерінің деңгейін зерттеуге және зертханалық сабақтарда интерактивті технологиялар мен АКТ қолданудың оның дамуына әсерін бағалауға арналған. Зерттеуге І.Жансүгіров атындағы Жетісу университеті және Ш.Есенов атындағы Каспий технологиялар және инжиниринг университетінің 6В01505 – «Информатика» және 6В01502 – «Математика-Информатика» білім беру бағдарламаларының студенттері қатысты, олар бақылау және эксперименттік топтарға бөлінді. Эксперименттік топта сабақ заманауи білім беру платформалары мен интерактивті құралдарды қолданып жүргізілді, бақылау тобында сабақ дәстүрлі түрде өткізілді. Экспериментке дейінгі және кейінгі онлайн сауалнамалардың нәтижелері эксперименттік топ студенттерінің АКТ құзыреттілік деңгейінің жақсарғанын көрсетті, бұл АКТ-ның болашақ мұғалімдерді даярлауға оң әсері туралы гипотезаны растайды. Мақалада педагогикалық білім беруді цифрландыру тәсілдерін одан әрі дамыту бойынша ұсыныстар берілген.

Кілтті сөздер: АКТ-құзыреттілік, болашақ мұғалімдерді даярлау, білім беруді цифрландыру, интерактивті технологиялар, зертханалық сабақтар, виртуалды технологиялар, педагогикалық информатика.

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РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ИНФОРМАЦИОННО-КОММУНИКАЦИОННЫХ КОМПЕТЕНЦИЙ БУДУЩИХ УЧИТЕЛЕЙ ИНФОРМАТИКИ

Статья посвящена исследованию уровня информационно-коммуникационных компетенций будущих учителей информатики и оценке влияния применения интерактивных технологий и ИКТ в лабораторных занятиях на его развитие. В исследовании приняли участие студенты образовательной программы 6В01505 – «Информатика» и 6В01502 – «Математика-Информоматика» Жетысуского университета имени И.Жансугурова и Каспийского университета технологий и инжиниринга имени Ш.Есенова, которые были разделены на контрольную и экспериментальную группы. Экспериментальная группа обучалась с использованием современных образовательных платформ и интерактивных инструментов, контрольная группа проходила занятия в традиционном виде. Результаты онлайн-опросов до и после эксперимента показали улучшение уровня ИКТ-компетентности у студентов экспериментальной группы, что подтверждает гипотезу о положительном влиянии ИКТ на подготовку будущих педагогов. В статье также даются рекомендации по дальнейшему развитию подходов к цифровизации педагогического образования.

Ключевые слова: ИКТ-компетентность, подготовка будущих учителей, цифровизация образования, интерактивные технологии, лабораторные занятия, виртуальные технологии, педагогическая информатика.

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