PROFESSIONAL TRAINING OF FUTURE DOCTORS USING CLOUD TECHNOLOGIES

FORMAÇÃO PROFISSIONAL DE FUTUROS MÉDICOS UTILIZANDO TECNOLOGIAS DE NUVEM

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Abstract. The conducted study aimed for the integration of cloud technologies into the educational process to evaluate their influence on different aspects of the professional competence of future doctors. For this, methods of comparative analysis, questionnaire, expert assessment, observation and statistical analysis were used. Results showed that students of the experimental group demonstrated significant improvement in the professional competence of such components as cognitive, motivational-volitional and organizational performance aspects. This confirms the importance of the skill to effectively use digital technologies in both professional and personal life spheres. The use of cloud technologies such as Google Docs, Pbwiki, Sway, Microsoft Azure, and Microsoft Planner led to significant improvements in students' results. Still, at the beginning, many teachers doubted these tools, although their attitude changed with time. Thus, reconsideration of educational programs to ensure their compliance with world education standards, in particular through the integration of new technologies, contributing to the development of professional competencies is relevant. The scientific novelty of the research is stipulated by the insufficient number of studies devoted to the use of cloud technologies in training future doctors.

Keywords: artificial intelligence, cloud technologies, digital technologies, network technologies, professional competence.

Resumo. O estudo conduzido teve como objetivo a integração de tecnologias de nuvem no processo educacional para avaliar sua influência em diferentes aspectos da competência profissional de futuros médicos. Para isso, foram utilizados métodos de análise comparativa, questionário, avaliação de especialistas, observação e análise estatística. Os resultados mostraram que os alunos do grupo experimental demonstraram melhora significativa na competência profissional de componentes como aspectos cognitivos, motivacionais-volitivos e de desempenho organizacional. Isso confirma a importância da habilidade de usar efetivamente as tecnologias digitais nas esferas da vida profissional e

pessoal. O uso de tecnologias de nuvem como Google Docs, Pbwiki, Sway, Microsoft Azure e Microsoft Planner levou a melhorias significativas nos resultados dos alunos. Ainda assim, no início, muitos professores duvidaram dessas ferramentas, embora sua atitude tenha mudado com o tempo. Assim, a reconsideração dos programas educacionais para garantir sua conformidade com os padrões mundiais de educação, em particular por meio da integração de novas tecnologias, contribuindo para o desenvolvimento de competências profissionais é relevante. A novidade científica da pesquisa é estipulada pelo número insuficiente de estudos dedicados ao uso de tecnologias de nuvem na formação de futuros médicos.

Palavras-chave: inteligência artificial, tecnologias de nuvem, tecnologias digitais, tecnologias de rede, competência profissional.

1. INTRODUCTION

Long-term medical education requires constant improvement with consideration of the personal and professional needs of future doctors, as well as updating the content of educational programs with the use of digital technologies and methods. Modern society defines new requirements for new types of doctor-specialists.

Therefore, professional competence is an inevitable element of qualitative education, which ensures the ability of future doctors to adequately use received knowledge in unpredicted situations, professionally grow during life and achieve high results in medical specialisation. Still, a doctor's practice provides not only the use of necessary theoretical knowledge and practical skills but also the establishment of professional relationships with colleagues and communication with patients, relatives, and friends. All these professional and personal characteristics define the professional competence of a doctor-specialist.

Future doctors should possess not only ordinary knowledge and skills in the medical sphere but also professional thinking and the ability to work in difficult situations (Levaillant, Levaillant, Lerolle, Vallet & Hamel-Broza, 2020; McGushin et al., 2023). The modern traditional educational system often fails to meet modern requirements. It is necessary to introduce modern digital technologies into the educational process to enhance the level of professional competences of future doctors.

Digital and interactive technologies improve educational processes, transforming information transmission systems. Our study aims to evaluate the effectiveness of cloud technologies used in the professional training of students of medical specialities. To achieve the set aim, the following main tasks were defined:

- To conduct a comparative analysis of available cloud technologies.
- To organise and conduct a survey among teachers concerning their experience of cloud technologies used in traditional education.
- To evaluate the level of professional competences development of students of medical faculties before the introduction of new technologies.
- To implement the experimental program with cloud technologies integration into the educational process.
- To evaluate the level of professional competencies development in students after implementation of the experimental program.
- To study the personal attitudes of teachers and students to the introduced cloud technologies.

The hypothesis of the study is that the integration of cloud technologies into the educational process of future doctors training will contribute to the improvement and development of their professional competencies.

2. LITERATURE REVIEW

In the modern era of globalization, information technologies underwent significant changes, and cloud technologies began to play an especially important role in the educational process. They contribute to the development of digital literacy of students and extend their possibilities in studying.

Cloud services become an integral part of modern education due to their ability to provide students and teachers with convenient and effective tools for work. The main advantage of these technologies is the possibility to use resources without additional expenses for software, which makes them accessible to all participants of the educational process. Scientific studies on cloud service implementation in higher educational institutions have significantly intensified.

Sarker, Wu, Cao, Alam, Monirul and Li, (2019) emphasize in his study that cloud technologies have great potential for educational process improvement. They not only enhance the level of student knowledge but also create an interactive educational environment, enabling the selection of different methods of education and the development of important competencies of students. Cloud services enable the use of innovative approaches in teaching, which is especially relevant in light of modern challenges in education such as distance and hybrid education.

Srikan, Pimdee, Leekitchwatana and Narabin (2021) show in his work that educational models with the use of cloud technologies are effective tools for critical thinking development and increase the informational literacy level of students. The use of cloud solutions enables students to get access to educational materials from any device, connected to the Internet, which is especially convenient for teachers, as it makes the joint work on projects and tasks online easier.

Such technologies form skills of teamwork and enable students to better interact with each other while studying (Al Rawajbeh, Hadid & Al-Zoubi, 2019). Fernanda, Huda and Fadri Geovanni (2023) note that one of the main advantages of cloud technologies use is their convenience for students, who can receive access to lecture materials at any time, being connected to the Internet.

Much attention in modern scientific literature is given to medical education modernisation. Within this context, different technological solutions, implementation, holding training with the use of novel methods (Kaufman, 2020), introduction of network technologies (Halkina, 2022) and 3D holography use (Haleem, Javaid, Singh, Suman & Rab, 2022) are actively studied. High-quality training of future doctors will always be an actual theme for scientific discussions, as human life and health depend on the professionalism of medical specialists.

It is also worth paying attention to the influence a doctor's confidence in their acts during practice has on their competence and ability to effectively perform their duties. Tan et al. (2021) and Martignon and Laskey (2019) note that specialists, who are highly confidential in their knowledge and skills, cope with their professional duties much better. This is confirmed by studies of Dave, Athaluri and Singh (2023), who indicate a tight relation between the level of professional confidence and general confidence of a doctor.

On the other side, modern studies prove that technology introduction into educational processes enables insurance for the development of highly professional personnel in medicine. Technological paradigms open new possibilities for future doctors' training, allowing teachers to effectively adapt educational programs to modern market requirements. Banerjee et al. (2021) note that technological innovations are especially important in training doctors as they enable the development of key competencies, necessary for successful practice in the modern world.

Marques da Rosa, Saurin, Tortorella, Fogliatto, Tonetto and Samson (2019) in their study analyse how technologies such as artificial intelligence, digital technologies and engineering

equipment are related to the sphere of health protection and can influence the professional development of nurses. The use of simulation and other innovative approaches in training doctors (Lee et al., 2021) can significantly improve communication between specialists of different medical professions and increase the level of teamwork, which is positively reflected in professional development during the whole life.

Herewith, the importance of high-quality training for future doctors is emphasised in scientific literature to be comprehensive and involve both theoretical and practical components (Tan et al., 2021; Keijzer-van Laarhoven et al., 2020). The high level of professional confidence of doctors is related to their ability to effectively work in difficult conditions and make correct decisions. According to Keijzer-van Laarhoven et al. (2020) and Zhao et al. (2023), confidence in their own acts helps doctors to better perform their duties and be competent specialists.

It is necessary to study the influence of cloud technologies on educational techniques in detail considering the requirements of modern medical education, which should train students in practical activities, in particular disease prevention and early diagnostics (Selway, Ellis & Thomas, 2019). Cloud computing introduction into pedagogical practice provides new possibilities for educational process optimisation. This enables teachers to select the best educational decisions among available variants and provides students with access to novel technologies for the development of their professional competence.

3. METHODS AND MATERIALS

Study procedure

The study was conducted during 2022-2023 and consisted of organisational, formative, and final stages (Figure 1).

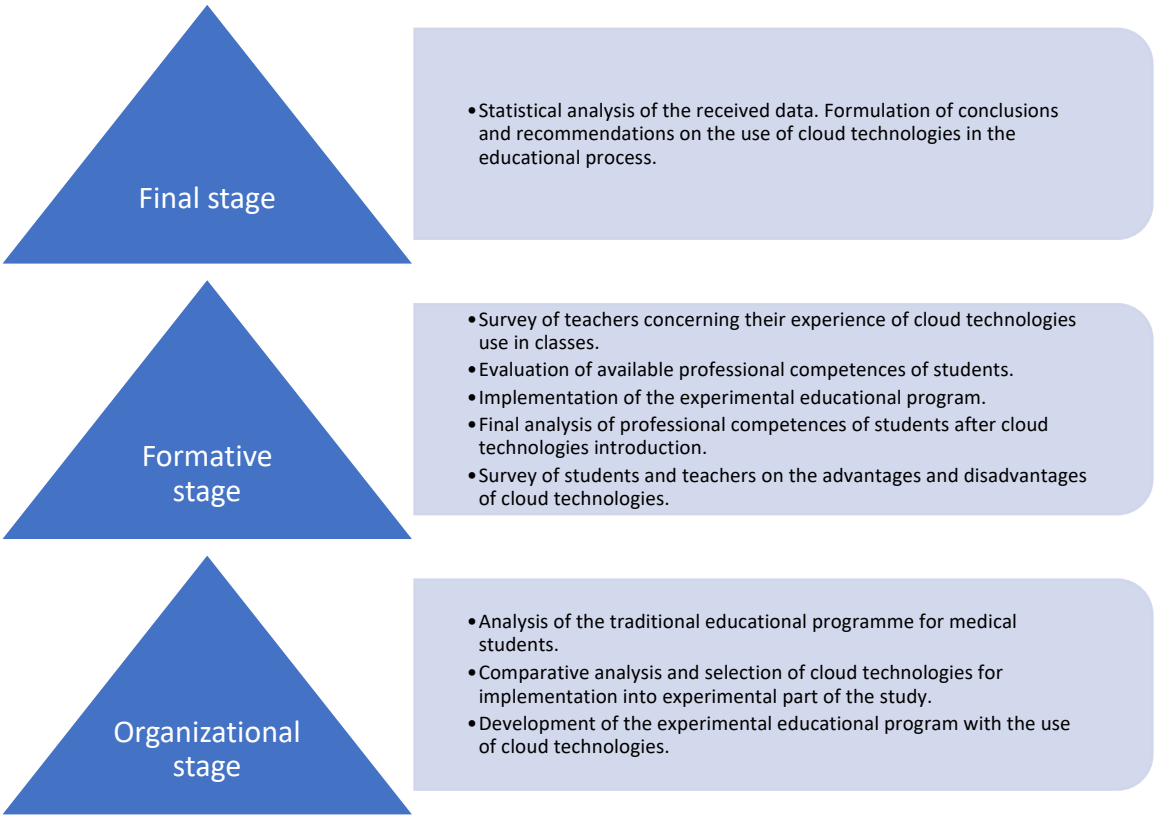

Figure 1. Stages of the conduction of the experimental part of the study.
Source: Author's development

The organizational stage included a detailed comparison of available cloud technologies. The main criteria for inclusion in the study were access to free use and the possibility of integration into the educational environment. Herewith, technologies with low ratings or only demo versions were not analysed (Table 1).

Based on these results, an analysis of traditional methods and tools that have already been used in the educational process was conducted. For this, a survey of teachers was organized. It aimed to determine traditional methods and tools used during lectures. Collected data presented a basis for the development of the experimental educational program, which provided for the active cloud technologies use in the professional training of future doctors.

Table 1. Overview of cloud technologies used in the study of the experimental group

Technology	Description	Logo
PBwiki	This technology was introduced for the development of communicative skills while working on creative group projects. Students of the experimental group were divided into teams for joint task performance. Using PBwiki, they could simultaneously edit and add new information, use website tools for collaborative work.	
Google News	This tool was used for home task performance, in particular for calculations and organising surveys. Students could work on documents jointly, which contributed to the development of team interaction.	
Sway	The Sway platform was used for the creation of interactive presentations. Students could assemble text, pictures, video and other elements, using various design layouts and colour schemes, which increased the creativity and effectiveness of the presentations.	
Microsoft Planner	This web application enables communication of students during task performance, forming teams and planning future meetings and activities, which improves the organization of the educational process.	
Microsoft Azure	Platform Microsoft Azure was offered to conduct testing of the students of the experimental group. Being an example of a hybrid cloud, Azure enables the conduction of large-scale tests of up to 5000 participants at the same time and automatic checks of their responses.	

In the formative stage, key components, being the basis of the professional competence of future doctors, were defined according to the model offered by Lymar and Omelchuk (2018) (Table 2). This model emphasises the necessary skills and knowledge to ensure high-quality healthcare services, as well as the development of critical thinking, emotional stability and the ability to continuously grow professionally.

Table 2. The main components of the professional competence of future doctors

Components	Peculiarities
Cognitive	Include general medical knowledge and basic deontological, ethical, legal and psychological aspects. They present the basis for understanding medical processes and standards of professional ethics, necessary for qualitative aid.
Motivational-volitional	The internal motivation of a doctor for professional activity, which is based on the conscious choice of the profession and value system. Additionally, this component covers all volitional qualities of a specialist, such as self-monitoring and self-regulation, which are important for the effective management of emotional stress a doctor faces while working with patients.
Organizational performance	Include skills of organization of work with patients and other participants of the medical process. A doctor may know how to organise work, but in practice, there are sometimes situations when incorrect strategies are chosen due to certain circumstances. This component also covers strategies for both verbal and non-verbal communication with patients.

Source: Developed by the author.

Sampling

The experimental part of the study was conducted on the basis of two higher educational institutions, namely: Taras Shevchenko National University of Kyiv and V. N. Karazin Kharkiv National University. The engagement of several institutions enabled the provision of a multifaceted approach to the study and the receipt of more substantiated and reliable conclusions.

250 students in 2-3 years of study were engaged for participation in the experiment. Inclusion criteria provided regular class attendance. Students having unsatisfactory grades were excluded from the sample. Generally, the sample was evenly divided into two groups: control group (CG) and experimental group (EG), each consisting of 125 students. Students of the control group continued education according to the traditional program, while an innovative program using interactive technologies was implemented for the experimental group.

Two educational courses in special disciplines of the field of Informatics “Programming” and “Computer Networks”, as well as a course in English for Professional Purposes were selected to confirm the hypothesis of the study. As these disciplines differ in teaching methods and learning activities, final results after the end of the experiment became important to confirm or refute a hypothesis.

Additionally to the student sample, 6 teachers with general work experience of 18 years participated in the study. They formed the expert group, which provided additional recommendations and evaluated the influence of experimental methods on the educational process and the quality of material mastering by students. This ensured more profound result analysis and enabled consideration of the experience of professionals in relevant fields.

Data collection

Comparative analysis. This method was used for cloud technologies comparison. In the result of the analysis, five technologies, corresponding to set criteria, were outlined.

Diagnostics of professional competencies. This method enabled comparison of the level of professional competence development before and after cloud technologies introduction. This enabled the evaluation of the effectiveness of these technologies in the improvement of educational program mastering.

Author’s survey. It was conducted to collect the opinions of students and teachers on cloud technologies use during the experiment. This enabled understanding of their perception and attitude to new methods of education.

Method of expert evaluations. The expert group analysed the results of the academic activity of students and teachers, studying the level of professional competence development of students of experimental and control groups.

Data analysis

Questionnaires created using Google Forms were used to collect data. Each questionnaire had 30 questions directed at the evaluation of each component of professional competence. The results were evaluated according to a 100-point scale:

- 0-30 points– competences were not formed;
- 30-45 points– competences were formed weakly;
- 45-70 points - formed, but require improvement;
- 70-100 points – formed well.

Cronbach Alpha coefficient and Pearson correlation coefficient were used to verify the validity and reliability of the questionnaire and ensured the reliability of the instruments of the study. IBM SPSS Statistics 25.0.0.1 software was used for quantitative data analysis. Pearson's criterion for correlation and Cohen's coefficient were calculated in the process of statistical results processing to measure the level of interaction between the variables.

Ethical criteria

The experimental study met all ethical and academic integrity standards. Before participation, all students signed informed consents, which guaranteed confidentiality of received data processing and non-disclosure of personal data. This ensured an ethical attitude to respondents and respect for their rights.

4. RESULTS

The survey of teachers concerning their experience of cloud technologies use in classes was conducted before experimental programme implementation in an educational environment (Fig. 2).

This enabled not only the evaluation of the relevance of selected technologies but also the determination of their advantages and disadvantages, which were noted during the integration of these technologies into the educational program.

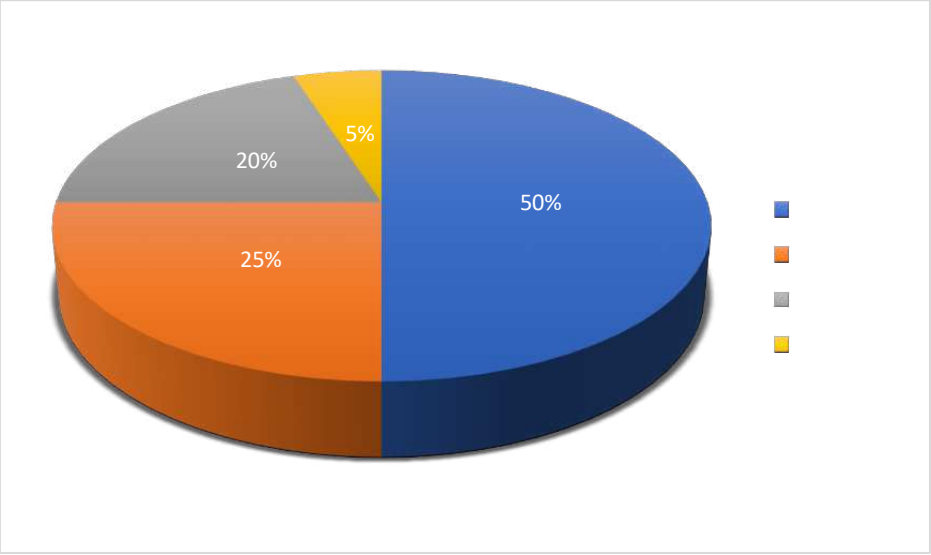

Figure 2. Distribution of teachers' responses on personal use of cloud technologies in the educational process. Source: Own development

Data analysis in Figure 2 shows that most teachers had no experience in cloud technology use. During the interview, they named several main reasons preventing this technology implementation into the educational process, in particular:

- difficulties in cloud technologies use - 35% of teachers, noted this to be the main obstacle;
- fear of personal data and educational materials' security - 8% of teachers expressed worries due to possible leakage or loss of information;
- excessive technologies choice - 5% of teachers noted that the wide variety of available cloud solutions made selection of the relevant platform difficult.

Besides the study of the experience of teachers, diagnostics of professional competences of students of the control (CG) and experimental (EG) groups before and after experimental program implementation. This enabled evaluation of the influence of cloud technologies on different aspects of professional competences of students, in particular: cognitive, motivational-volitional and organizational performance components (see Table 3-5).

Table 3. Analysis of the distribution of evaluation of the cognitive component of professional competence of students of control and experimental group before and after cloud technologies implementation

Cognitive component	CG			EG		
	Before (x)	After (x)	R	Before (x)	After (x)	R
Knowledge of medical terminology and its correct usage	37	75	32	39	74	33
Understanding of pathophysiological processes and mechanisms of disease development	25	71	41	25	76	46
Study of medications: their pharmacological action, possible side effects and interaction between medications	47	70	28	39	67	26
Learning diagnostic methods, including laboratory tests, instrumental examinations and other methods, as well as the development of treatment strategies and therapy plans	35	48	14	40	66	21
Understanding ethical norms in medicine and compliance with professional standards	37	52	12	39	72	24
Development of skills in critical thinking, study conduction and commitment to continuous professional development	45	57	15	41	65	20
Understanding of the structure of the healthcare system, legislative framework and work of regulating authorities	41	65	23	39	79	38

Source: Author's own development | Where x - average value

Analysis of results shows that cloud technologies implementation significantly affected different aspects of professional competences of students In particular, skills of disease diagnostics and analysis conduction significantly improved: in the control group (CG) the result was R=14, while in the experimental group (EG) this parameter achieved R=22. A significant increase in knowledge of ethical norms and professional standards was also noted: in CG the results were R=11, and in EG - R=24.

The opposite situation was observed in relation to knowledge of regulatory acts in the healthcare sphere: CG had higher indications (R=37) compared to EG (R=22). This may be explained by the fact that the experimental program was focused on the discipline "Medical Law of Ukraine", which contributed to better material mastering by the students of the EG and positively influenced their results in relevant spheres.

Table 4. Analysis of the distribution of evaluation of the motivational-volitional component of professional competence of students of control and experimental group before and after cloud technologies implementation

Motivational-volitional component	CG			EG		
	Before (x)	After (x)	R	Before (x)	After (x)	R
Building professional motivation	66	71	-1	73	75	2
Development of empathy skills and skills of effective communication with patients	48	70	21	39	65	24
Understanding and compliance with ethical norms and professional values	59	66	8	47	63	15
Ability to cope with stressful situations	42	54	11	43	74	28
Fostering self-discipline and control of one's own will	35	59	19	39	71	33
Ability to make decisions even in difficult and unpredicted conditions	34	58	15	37	77	41
Commitment to continuous self-improvement, professional level advancement and readiness to invest time and efforts in the improvement of the quality of medical activity	62	69	1	69	79	12

Source: Author's own development | Where x - average value

The results indicate significant improvements in students of the experimental group in the following aspects: understanding of professional ethical norms, stress resistance, ability to make decisions quickly, and motivation for continuous professional development and lifelong learning.

Higher indicators in these spheres may be related to the teachers' active use of creative tasks for teamwork. Students independently organized meetings, shared duties and jointly solved disputes and controversies, which fostered the development of teamwork and self-regulation skills.

Table 5. Analysis of the distribution of evaluation of the organizational performance component of professional competence of students of control and experimental group before and after cloud technologies implementation

Organizational performance component	CG			EG		
	Before (x)	After (x)	R	Before (x)	After (x)	R
Clinical skills	47	72	24	51	76	23
Development and implementation of therapy plans (medication prescription, physiotherapy, surgery, medical procedures)	58	63	10	49	66	17
Effective communication with patients (understandable and empathic explanation of medical information)	57	69	11	51	77	26
Medical documental recording	25	41	16	32	79	49
Work with medical facilities and equipment (visit planning, working time organization)	24	60	36	18	69	50
Knowledge of legislation, ethics, and professional standards	21	47	26	21	77	57
Time and resource management for high-quality medical aid provision	41	47	7	46	76	31

Source: Author's development | Where x - average value

Evaluation of organizational performance component demonstrated significant differences between the results of experimental and control groups. Students, who used cloud technologies in studying, showed better time management skills for medical aid provision, a better understanding of professional standards and norms, as well as better developed communication skills compared to students, who studied according to the traditional program.

The decision to conduct additional surveys to collect opinions on the use of offered cloud technologies in the educational process was made after diagnostics of the level of developed professional competencies. Not only students but also teachers participated in the survey, which enabled the receipt of a multi-faceted view on the implementation of new technologies. Results of this survey are presented in Table 6, where the attitude of both groups to the use of cloud technologies, their advantages and possible disadvantages in the educational process were analysed in detail.

Table 6. Results of the survey of teachers and students of the experimental group on cloud technology use after the end of the experiment.

Students	Yes (%)	No (%)
How convenient was the use of cloud technologies for access to learning content from any device?	94	6
Did cloud technologies contribute to the improvement of joint work and information exchange with other students and teachers?	93	7
How do you evaluate the level of security of your personal data, stored in cloud storage used in the educational process?	73	27
Teachers		
How do you evaluate the efficiency of cloud technologies use for ensuring access of students to academic content?	98	2
Do you plan to further use cloud technologies for joint work and communication with other teachers and students?	94	6
Do you believe cloud technologies are facilitating the process of teaching lessons and evaluating the academic achievements of students?	90	10
What do you think about the protection of personal data and academic material using cloud technologies?	88	12

Source: Author's development

Survey results showed that in general, students positively evaluated cloud technologies in the educational process. They noted the convenience and accessibility of educational materials due to these technologies. Still, both students and teachers express a certain fear of personal data storage in cloud storages.

Teachers recognized cloud technologies to be an effective instrument in organising students' access to educational materials and improving the quality of education. It is worth noting that 94% of teachers plan to continue cloud technologies use in future classes, admitting their advantages in simplifying the educational process.

The results were subjected to detailed statistical analysis after the end of the study. The use of the Pearson criterion enabled the detection of the clear tendency for results improvement among students of the experimental group, who studied with the use of cloud technologies, compared to those, who continued studying according to traditional methods.

This certifies the positive influence of cloud technologies on the development of professional competencies of students of medical specialities. These findings confirm the hypothesis we put forward that cloud technology integration into the educational process can significantly improve academic achievements.

Analysis of Cohen's coefficient, which evaluates the effectiveness of the implementation of new technologies, showed values from 0.77 to 1.19 for the experimental group. This indicates the great effect of cloud technologies on academic results.

Cohen's coefficient was 0,55 for students studying according to the traditional program, which demonstrates the average effect and confirms that compared to new technologies traditional teaching methods have a lower influence on the improvement of professional competencies.

5. DISCUSSION

The study confirmed that the hypothesis put forward earlier was applied to cloud technologies, which contributed to the development of professional competencies of future doctors. Students, who participated in the experiment, showed better results in the development of cognitive, motivational-volitional and organizational performance components of professional competence. These results are similar to the conclusions of the group of researchers, including Sabadash, Melinyshyn, Oliinyk and Petriv (2023), who note that cloud technologies provide additional possibilities for educational process organization, foster improvement of academic achievements and realization of educational tasks.

The use of cloud instruments such as PBwiki, Google News, Sway, Microsoft Planner and Microsoft Azure demonstrated its effectiveness in students' professional development. The experiment shows that consequent work with these technologies significantly improves the development of professional skills through their integration into the educational system. Mosenkis, Lukianyk, Strokal, Ponomarova and Mykhailiuk (2020) note similar results. They found that cloud technologies are an efficient instrument for improving all components of professional competence, in particular that of teachers. Cloud technologies become a key means of interaction between faculty and students in a distant form of education, and they are used to solve the issue of educational process organization.

These innovations have significantly changed teachers' attitudes to the use of digital instruments. At the beginning of the experiment, most of them considered cloud technologies to be inconveniences, dangerous and ineffective for the educational process. However, teachers gradually changed their attitude toward these tools, understanding their advantages during the experiment.

The study by Ashtari and Eydgahi (2017) confirms that many teachers do not use cloud systems initially due to low digital competence or lack of need. Findings of other scientists (Fernández-Batanero, Román-Graván, Montenegro-Rueda, López-Meneses & Fernández-Cerero, 2021; Hinojo-Lucena, Aznar-Diaz, Caceres-Reche, Trujillo-Torres & Romero-Rodriguez, 2019) also confirm this, indicating that insufficient digital skills among teachers create obstacles to the introduction of novel technologies.

However, the introduction of new courses and technologies on the basis of cloud solutions can be the basis for the formation of an integral system for the development of professional and digital competency of future doctors. Modern technologies, in particular, in medical practice, have great potential for the improvement of the effectiveness of diagnostics, quality of medical services and medical facilities management (Senbekov et al., 2022; Valiee et al., 2023). Thus, technological progress does not only improve the educational process, which directly affects the quality of future professional activity of doctors.

6. CONCLUSION

The study showed that in the digitalization world, skills of digital technology usage are of higher importance both for work and everyday life. For example, students who used cloud services such as Google Docs, Pbwiki, Sway, Microsoft Azure, and Microsoft Planner showed significant improvements in education.

In the beginning, many teachers expressed doubts concerning these instruments, but their attitude changed during the experiment, and they admitted the benefits of cloud technologies for classes. Adaptation of the educational programs to modern requirements, directed at the development of professional skills of students and improvement of their learning method, is one of the main methods of updating education and entering the global educational space.

The use of cloud technologies in higher educational institutions has numerous advantages, for example, savings on equipment and licences, the ability to conduct online tests and create

an open educational environment. The variety of instruments, used during classes, contributes to better material mastering by students.

The study showed that the use of cloud technologies is the most effective for training future medical specialists. This novel study indicates that little attention has been paid to cloud technologies use in medical education. The possible direction of future studies may be virtual reality technologies use for practical training of students. This will help to improve the educational process and increase the quality of medical education.

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