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Digital Competence of Medical Students as a Component of Professional Training in the Context of Healthcare Digitalization

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Abstract. The digital transformation of the healthcare system has significantly changed the requirements for the professional training of future doctors. The active implementation of electronic medical records, telemedicine, artificial intelligence, virtual simulators and digital communication technologies in medical practice requires the formation of a high level of digital competence in medical students. Digital competence is considered not only as basic computer literacy, but as a complex professional characteristic that combines technical readiness, information literacy, digital communication, analytical and cognitive skills, as well as ethical and legal awareness of the use of digital technologies in healthcare. The aim of the article is to study the problem of digital competence of medical students and determine its significance for future professional activities. The study is based on the analysis of scientific publications devoted to digital competence in medical education. Scientific sources from PubMed, Scopus, Web of Science and Google Scholar databases were analyzed using keywords related to digital literacy, telemedicine, electronic health records, artificial intelligence in medical education and professional training of healthcare professionals. The analysis included review, systematic and empirical studies that describe the concepts, models, educational programs and results of the development of digital competencies. The results of the study showed that digital competence is an important component of modern medical education and professional readiness of future doctors. The main components of digital competence are technical skills for working with digital medical systems, information literacy for searching and critically evaluating scientific information, communication skills for professional interaction in a digital environment, analytical skills for making clinical decisions using digital technologies, as well as ethical and legal responsibility for protecting medical data and ensuring patient confidentiality. A high level of digital competence contributes to improving the quality of medical education, patient safety, the effectiveness of clinical communication and the readiness of graduates to work in the conditions of digitalization of the healthcare system. The integration of digital competences into all stages of medical education is an important condition for the professional development of future doctors.

Keywords: digital competence, digital literacy, medical education, medical students, telemedicine, digital technologies.

Цифрова грамотність студентів-медиків як складова професійної підготовки в контексті цифровізації охорони здоров'я

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Цифрова трансформація системи охорони здоров'я суттєво змінила вимоги до професійної підготовки майбутніх лікарів. Активне впровадження електронних медичних записів, телемедицини, штучного інтелекту, віртуальних симуляторів та цифрових комунікаційних технологій у медичну практику потребує формування у студентів-медиків високого рівня цифрової компетентності. Цифрова компетентність розглядається не лише як базова комп'ютерна грамотність, а як комплексна професійна характеристика, що поєднує технічну готовність, інформаційну грамотність, цифрову комунікацію, аналітичні та когнітивні навички, а також етичну і правову обізнаність щодо використання цифрових технологій у сфері охорони здоров'я. Метою статті є дослідження проблеми цифрової компетентності студентів-медиків та визначення її значення для майбутньої професійної діяльності. Дослідження ґрунтується на аналізі наукових публікацій, присвячених цифровій компетентності в медичній освіті. Було проаналізовано наукові джерела з баз даних PubMed, Scopus, Web of Science та Google Scholar із використанням ключових слів, пов'язаних із цифровою грамотністю, телемедициною, електронними медичними записами, штучним інтелектом у медичній освіті та професійною підготовкою медичних працівників. До аналізу включено оглядові, систематичні та емпіричні дослідження, які описують концепції, моделі, освітні програми та результати розвитку цифрових компетентностей. Результати дослідження засвідчили, що цифрова компетентність є важливою складовою сучасної медичної освіти та професійної готовності майбутніх лікарів. Основними компонентами цифрової компетентності є технічні навички роботи з цифровими медичними системами, інформаційна грамотність щодо пошуку та критичної оцінки наукової інформації, комунікаційні навички для професійної

взаємодії у цифровому середовищі, аналітичні здібності для прийняття клінічних рішень із використанням цифрових технологій, а також етична й правова відповідальність за захист медичних даних і забезпечення конфіденційності пацієнтів. Високий рівень цифрової компетентності сприяє підвищенню якості медичної освіти, безпеки пацієнтів, ефективності клінічної комунікації та готовності випускників до роботи в умовах цифровізації системи охорони здоров'я. Інтеграція цифрових компетентностей у всі етапи медичної освіти є важливою умовою професійного розвитку майбутніх лікарів.

Ключові слова: цифрова компетентність, цифрова грамотність, медична освіта, студенти-медики, телемедицина, цифрові технології.

Introduction

Topicality of the problem.

Healthcare is becoming increasingly digital and is transforming clinical practice as well as the medical education system [1, 2, 3]. The use of electronic medical records, telemedicine platforms, virtual simulators, artificial intelligence-based curricula and other digital technologies is becoming an important requirement for the training of modern doctors [4]. This has led to a new educational need, medical students must be digitalized, they must have a set of skills to effectively use modern technologies in the field of medicine in education, research and practice in clinical work with patients [5].

Digital competencies cover not only basic computer and office skills, but also more advanced competencies, including the ability to critically evaluate information found in electronic sources, communicate effectively using digital communication, use professional medical software and implement advanced technologies in clinical practice [6, 7]. These skills are not taught consistently, integratedly and in a timely manner, so that medical students and graduates are not sufficiently prepared for the demands of modern professional practice [8].

Digital competences are a key aspect of professional development, and a high level of digital literacy can contribute to effective teaching, clinical thinking, independent learning and professional development, as well as the quality of healthcare and patient safety [9, 10]. When studying students' digital competences, analyzing their level and identifying the most important competences and methods for their development is not only a relevant academic problem, but also a practically significant task that affects the preparation of future doctors for the challenges of modern healthcare, a task that is gaining increasing importance.

Literature review.

An important contribution to research on digital competences in medical education is the work by Khurana et al (2020), in which, using a scoping review and the Delphi method, over 40 key themes were identified across three main subcategories knowledge, skills and attitudes which should be incorporated into medical school curricula [11]. It highlights the fact that digital competences are not just technical but also comprehensive and must be nurtured in the future health practitioners to prepare themselves for digital health.

During the COVID-19 pandemic, Lotrean et al. (2023) explored the training, attitudes and intentions of medical students in Romania towards the use of digital health technologies [12]. The authors polled the 5th and 6th year students from the University of Medicine in Cluj-Napoca to evaluate their previous training and future needs for digital health education, the attitude towards digital tools and their intentions as doctors, and the connection between learning, attitudes and intentions and the socio-demographic factors. The findings revealed that less than half of the students had prior experience in digital health but most students wanted to learn more and advocated for a formal course on digital health being incorporated in the curriculum. Attitudes and intent of the students were positive, especially for prevention; there were some differences based on gender and previous learning for patient management and diagnosis/treatment. The article emphasizes the importance of embedding a

digital health curriculum into the medical education system, with a view to equipping the next generation of doctors for the digitalisation of health services.

Schaal et al. (2025) examine the digital competence of students in the fields of healthcare and nursing in Germany, Ukraine and Kazakhstan [13]. The authors provide comparisons of student self-assessments on five areas: data processing and evaluation, collaboration and communication, digital content creation, security, and problem solving. There was, overall, a high level of digital competence, with results showing the German students underrating their competence in creating digital content, and open-ended responses showing a methodologically high level of information-seeking strategies, such as systematic literature reviews and the use of Boolean operators. The students from Ukraine resorted to more heuristic and comparative ways while the students from Kazakhstan used pragmatic approaches adjusted to the available infrastructure. The article emphasizes the difference between self-assessment and actual competence, underscores the importance of integrated digital skills training, and suggests the creation of special micro-modules to enhance practice-oriented skills in the digital health care environment.

This article by Zuccotti et al. (2026) discusses digital literacy and the readiness of medical students and residents in five Italian universities to use telemedicine [14]. This study employs a cross sectional survey of technical competence and behavioural readiness, including experience, attitudes and intentions about the use of telemedicine. The results indicated that 68% of the respondents had heard of telemedicine, but only 22% had personal experience and 13% academic experience. Concurrently, 83% strongly wanted to go for telemedicine and training. The factors that predicted being ready for telemedicine included enthusiasm for technology, confidence in using a smartphone, and level of digital literacy (eHEALS). The authors stress that high interest goes hand in hand with uneven level of readiness and that training programmes should thus include structured, long-term digital health training along with technical, ethical and behavioural skills, in order to equip doctors to be able to provide technology-driven, patient-centred health care.

Digital skills are becoming an integral part of medical students' training. These include the technical skills of computer and office software, as well as the critical appraisal of information, effective communication through digital means and specialist medical software skills. These skills can be applied across different medical fields: telemedicine allows doctors to consult patients remotely and monitor their chronic conditions, electronic health records enable management of patient histories and analysis of clinical data, virtual simulators and AR/VR technologies offer a safe learning environment for practising clinical skills, and AI-based training programmes customise learning based on individual needs and evaluate practical training results. Using these technologies in training programs can enhance the level of training for future physicians, and prepare them to work in a modern digital clinical environment.

The theoretical frameworks that describe the competencies needed in today's society are recognized by many studies, but the actual teaching practices in universities do not include them. This shows the importance of continuing research into the most effective ways of incorporating digital competencies in the curriculum, and the need for a harmonization of learning outcomes in digital competency assessment.

The goal of the article: to examine the problem of digital competence of medical students and determine its importance for their future work.

Methodology.

Systematic and critical analysis of academic publications were used as methods to analyze the digital competences of medical students in the context of their professional

training. The study concentrates on literature on digital skills development in medical education from academic and educational sources, as well as methodological approaches. The literature search was performed in four international databases: PubMed, Scopus, Web of Science and Google Scholar with the following keywords and combinations of keywords: digital competence, digital literacy, digital skills, eHealth, telemedicine, electronic health records, virtual simulators, AI in medical education, medical students, health professions education, professional development. The publications were chosen, which included review, systematic and empirical studies, describing concepts, models, programmes and outcomes of digital competence development in medical educational institutions. The weakness of the review is that it has been based exclusively on the publications written in the English language and that it is not based on primary empirical data from individual educational institutions, but rather on general patterns of the development of digital competences. The method enables knowledge systematisation which leads to the recommendations for incorporating digital competences into curricula, along with strengthening the competencies of future doctors.

Results

The analysis and critical study of academic literature enabled identification and systemisation of the key areas of digital skills relevant to medical students during the process of digital transformation of health care. The results retrieved suggest that the concept of digital competence in medical education should not be viewed as limited to the utilization of a computer or working with typical software. It is a complex and multidimensional element of the professional competence in the modern educational and clinical context, containing technical, informational, communicative, analytical, cognitive, ethical and legal elements. These components are interdependent and collectively shape the future physicians' effectiveness, safety, and responsible use of digital technologies in education, research and clinical practice [15, 16].

Technical readiness is one of the basic components of digital competence required when working with increasing use of digital tools in medical education and healthcare. This group of competencies includes the ability to use computer systems, electronic health records, specialized medical software, telemedicine platforms, digital databases, virtual simulators and other technological resources [17, 18]. These abilities are relevant not only in terms of general digital literacy but also in terms of future professionals' activities for medical students. Enabling students to maneuver digital clinical environments, enter and interpret electronic medical data, work with diagnostic platforms and educational platforms and utilize simulation technologies provide the basis for practical training near to real clinical practice. Technical skills should also not be seen as enough on their own, as the mechanical use of digital tools doesn't mean that the information given is interpreted correctly in the clinical situation or that it enables the right professional decisions.

Information literacy is another important part, that is closely linked with the principles of evidence-based medicine. This includes searching for medical information in electronic databases, evaluating the reliability and relevance of scientific information, identifying verified scientific information from incomplete or outdated information, and organizing the information retrieved for educational, research and clinical uses [19, 20]. It is especially relevant in the preparation of doctors, as the level of critical evaluation of scientific information is a key factor in the clinical reasoning and decision-making processes. The rapid increase in the amount of medical data available online makes this skill especially relevant. Students may struggle with identifying relevant and reliable evidence, composing research papers, understanding clinical guidelines and using scientific evidence in practice without sufficient information literacy skills [21].

The demand for professional communication skills in digital environments, involvement in remote consultations, working with patients in telemedicine, and working together in interdisciplinary teams and virtual environments has grown in recent years in the field of medicine [22, 23]. These skills are essential as communication in the digital world is different than traditional face-to-face communication, and it must be clear, accurate, ethical and have professional boundaries. The quality of communication can have an impact on the patient's understanding of medical recommendations, adherence to treatment, continuity of care, and overall satisfaction with medical services in telemedicine. Thus, the ability to communicate digitally can be considered to be one of the necessary elements of patient-centred medical practice [24].

Analytical, cognitive skills in the use of digital technologies for clinical reasoning, data analysis and decision-making form another group. These competencies include the ability to interpret patient data, evaluate laboratory and instrumental findings, use statistical methods, work with digital research tools, understand the principles of clinical decision support systems and critically assess the possibilities of artificial intelligence in medicine [25, 26]. These skills develop critical thinking and clinical judgement, particularly when the doctor must deal with a great deal of conflicting information. Digital technologies can be used to assist the diagnostic process, enhance access to information and assist in the analysis of clinical situations. They should not take the place of the doctor's professional thinking, however. Rather, they should serve a purpose of supporting clinical judgement and improve the choice of future physicians [27].

Ethical and legal aspects of digital competence should be discussed separately. Medical students need to have an understanding of the principles of confidentiality, safeguarding personal health information, cyber security, the responsible use of technology and adherence to professional and legal requirements. This is especially crucial, as medical information is sensitive and any breaches in privacy or misuse of medical data could have significant repercussions for patients, healthcare providers, and medical facilities [28, 29]. Upcoming physicians must be familiar not only with the technical aspects of safeguarding information, but also with the ethics of utilizing electronic health records, telemedicine methods, digital communication systems and artificial intelligence systems [30, 31]. So, ethics and lawfulness provide the foundations for safe, trustworthy digital medicine.

An analysis of the results also reveals that digital competence should not be developed exclusively in isolated courses of medical informatics or information technologies. This could give students some basic competences but not help them to apply them systematically in thinking and conduct during clinical encounters. The training in digital competences should be woven into the whole educational framework of medical education, encompassing clinical disciplines, simulation training, evidence-based medicine, telemedicine, research methodology and practical clinical training [32, 33]. Digital tools can be applied in clinical disciplines in regard to the interpretation of diagnostic data, in electronic documentation, in clinical decision support and in communication with patients. In simulation education, students can learn decision making in a safe and controlled environment through the use of virtual simulators and digital clinical scenarios. Digital competence is required in evidence-based medicine and research training for literature search, working with databases, statistical analysis, writing scientific papers and critical appraisal of scientific evidence. In telemedicine, it is the foundation for successful communication across the distance from patient to patient and patient to healthcare providers [34].

It is also important to highlight the need for continuity and progressive complexity in educational activities to build digital competence. Students need to develop essential skills in information literacy, educational applications and electronic resources at the early phases of training.

Discussion

Interpretation of results

Digital competence of medical students is not a separate technical skill, but a complex component of their professional training. Its content covers technical readiness to work with digital tools, information literacy, digital communication, analytical and cognitive skills, as well as ethical and legal aspects of the use of digital technologies in medicine.

Modern medical practice is increasingly dependent on electronic medical records, telemedicine, digital databases, simulation technologies, artificial intelligence and clinical decision support systems. Accordingly, a future doctor must not only be able to use digital tools, but also critically evaluate information, interpret clinical data, adhere to the principles of confidentiality and security, and maintain professional responsibility when using technologies.

It is particularly important that technical skills alone do not guarantee the effective use of digital technologies in clinical practice. Mechanical mastery of programs or platforms does not mean the ability to correctly interpret medical information, make informed decisions, or ensure safe interaction with the patient. That is why digital competence should be considered as an integrated component of clinical thinking, evidence-based medicine, professional communication, and ethical responsibility of the future doctor.

Development of digital competence cannot be limited to separate courses in medical informatics or information technology. Such disciplines can form basic skills, but do not ensure the systematic application of digital tools in clinical situations. It is more effective to integrate digital competences into different stages of medical education: clinical disciplines, simulation training, telemedicine, evidence-based medicine, research work, and practical training.

Scientific novelty

The scientific novelty of the study lies in the systematization of the key components of the digital competence of medical students in the context of their future professional activities. The digital competence of medical students is considered as a multi-component professional characteristic that combines technical readiness, information literacy, digital communication, analytical and cognitive skills, ethical responsibility and legal awareness. The approach to understanding digital competence in medical education has been improved by interpreting it not only as general digital literacy, but as a condition for effective clinical training, evidence-based thinking, safe work with medical data and professional interaction with patients in a digital environment.

The position on the need to integrate digital competences into the entire educational process of a medical university has been further developed. It is justified that their formation should not occur in isolation within individual disciplines, but through clinical subjects, simulation training, telemedicine, evidence-based medicine, research activities and practical training.

Practical significance

The practical significance of the results obtained lies in the possibility of their use for improving educational programs in medical institutions of higher education. The proposed understanding of digital competence can be useful for teachers, curriculum developers, administrations of medical universities, departments of medical informatics, clinical disciplines, simulation centers and organizers of postgraduate medical education.

Conclusions

Digital competence among medical students is a vital component of their professional training, as modern medicine increasingly relies on electronic health records, telemedicine, digital databases, simulation technologies, artificial intelligence and other digital tools. The digital competence of a future doctor is not limited to basic computer skills, but encompasses technical readiness, information literacy, digital communication, analytical and cognitive

skills, ethical responsibility and knowledge of the legal requirements for working with medical information. Information literacy is of particular importance for medical students, as the ability to find, critically evaluate and use scientific medical information is a prerequisite for evidence-based medicine, clinical reasoning and the making of professionally sound decisions. Digital competences should not only be developed within the framework of individual courses in medical informatics, but should be integrated into the entire process of medical education, in particular into clinical disciplines, simulation training, telemedicine, research activities and practical training. A high level of digital competence among future doctors is of practical importance for improving the quality of medical education, patient safety, the effectiveness of clinical communication, and the readiness of graduates to work in the context of the digital transformation of the healthcare system.

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