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FORMATION OF DIGITAL COMPETENCIES IN FUTURE COMPUTER SCIENCE TEACHERS USING TECHNOLOGIES OF INTERNET OF THINGS

Abstract

In order for future teachers to effectively utilize IoT technology in the classroom, it is essential for them to develop IT competencies. This includes having the knowledge and skills to integrate IoT devices and platforms into their teaching practices, as well as the ability to analyze and interpret data collected from these devices. The formation of IT competencies using IoT for future teachers is crucial in preparing them to navigate the ever-evolving landscape of technology in education. Teachers must be able to perceive technology as an important element of their present and future lives and recognize its essential role in the development of their countries. Furthermore, teachers need to understand that the way students learn in the 21st century is different from traditional methods, and they must adapt their teaching practices to accommodate technology and harness its potential in enhancing student learning. One of the challenges in the field of education in the era of the industrial revolution 4 is the use of internet technology in learning, which is part of 21st century learning. This study made an effort to give a broad overview of current trends and unresolved issues in using IoT-based teaching and learning and its applications in diverse fields. The investigation performs a bibliometric analysis to focus on peer-reviewed research articles published in well-known publications databases. The findings of this study should also act as a strong incentive for universities and colleges to use IoT-based teaching and learning technology for improved academic achievement.

Keywords: internet of Things, education, modern trends, digital competencies.

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ЗАТТАР ИНТЕРНЕТІ ТЕХНОЛОГИЯЛАРЫН ПАЙДАЛАНУ АРҚЫЛЫ БОЛАШАҚ ИНФОРМАТИКА МҰҒАЛІМДЕРІНІҢ ЦИФРЛЫҚ ҚҰЗЫРЕТТІЛІКТЕРІН ҚАЛЫПТАСТЫРУ

Аннотация

Болашақ мұғалімдер сабақта IoT технологиясын тиімді пайдалануы үшін олардың IT құзыреттілігін дамыту өте маңызды. Бұған IoT құрылғылары мен платформаларын оқыту тәжірибесіне біріктіру бойынша білім мен дағдылардың болуы, сондай-ақ осы құрылғылардан жиналған деректерді талдау және түсіндіру мүмкіндігі кіреді. Болашақ мұғалімдер үшін IoT-ті пайдалана отырып, AT құзыреттілігін қалыптастыру оларды білім берудегі технологияның үнемі дамып келе жатқан кеңістігінде өте маңызды. Мұғалімдер технологияны қазіргі және болашақ өмірінің маңызды элементі ретінде қабылдай білуі және оның өз елдерінің дамуындағы маңызды рөлін мойындай білуі керек. Сонымен қатар, мұғалімдер 21-ші ғасырда оқушылардың білім алу тәсілі дәстүрлі әдістерден ерекше екенін түсінуі керек және олар оқыту тәжірибесін технологияға сәйкестендіруге және оның студенттердің оқуын арттырудағы әлеуетін пайдалануға бейімдеу керек. 4-өнеркәсіптік революция дәуіріндегі білім беру саласындағы мәселелердің бірі – 21 ғасырдағы оқытудың бір бөлігі болып табылатын оқытуда интернет технологиясын пайдалану. Бұл зерттеу IoT негізіндегі оқыту мен оқуды және оның әртүрлі салалардағы қолданбаларын пайдаланудағы қазіргі тенденциялар мен шешілмеген мәселелерге кең шолу жасауға күш салды. Зерттеу белгілі басылымдардың дерекқорларында жарияланған рецензияланған ғылыми мақалаларға бағытталған библиометриялық талдау жүргізеді. Бұл зерттеудің нәтижелері университеттер мен колледждерге оқу жетістіктерін жақсарту үшін IoT негізіндегі оқыту мен оқу технологиясын қолдануға жоғары ынталандыру болуы керек.

Түйін сөздер: интернет заттары, білім беру, заманауи трендтер, цифрлық құзыреттер.

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ФОРМИРОВАНИЕ ЦИФРОВЫХ КОМПЕТЕНЦИЙ БУДУЩИХ УЧИТЕЛЕЙ ИНФОРМАТИКИ С ИСПОЛЬЗОВАНИЕМ ТЕХНОЛОГИЙ ИНТЕРНЕТА ВЕЩЕЙ

Аннотация

Для эффективного использования будущими учителями технологии Интернета вещей в классе им необходимо развивать ИТ-компетенции, что включает в себя наличие знаний и навыков для интеграции устройств и платформ Интернета вещей в учебную практику, а также способность анализировать и интерпретировать данные, собранные с этих устройств. Формирование ИТ-компетенций с использованием Интернета вещей для будущих учителей имеет решающее значение для их подготовки к навигации в постоянно меняющемся мире технологий в образовании. Учителя должны быть способны воспринимать технологии как важный элемент своей нынешней и будущей жизни и признавать их важную роль в развитии своих стран. Кроме того, учителя должны понимать, что способы обучения учащихся в 21 веке отличаются от традиционных методов, и они должны адаптировать свою практику преподавания с учетом технологий и использовать их потенциал для улучшения обучения учащихся. Одной из проблем в сфере образования в эпоху промышленной революции 4 является использование интернет-технологий в обучении, которое является частью обучения 21 века. В этом исследовании была предпринята попытка дать широкий обзор текущих тенденций и нерешенных проблем в использовании преподавания и обучения на основе Интернета вещей и их применения в различных областях. В исследовании проводится библиометрический анализ, направленный на рецензируемые научные статьи, опубликованные в базах данных известных изданий. Результаты этого исследования также должны послужить сильным стимулом для университетов и колледжей использовать технологии преподавания и обучения на основе Интернета вещей для улучшения академической успеваемости.

Ключевые слова: интернет вещей, образование, современные тенденции, цифровые компетенции.

Introduction. Nowadays the use of IoT Technologies is becoming a vital part of the education process. The Internet of Things is a network of interconnected devices, sensors, and people who also participate in the process of transferring data among the network. The Internet of Things (IoT) sector has great potential to deliver internet-connected devices that can enhance the well-being of individuals, families, and communities. Implementing IoT in education allows universities and schools to monitor individual student's actions including attendance, time, and results, to analyse the collected data.

Recently vast variety of IoT technologies has been used in the education process to improve productivity and enhance the quality of knowledge acquisition. Therefore, to understand the principles of their implementation and the features of their use, there was a need to consider the types of IoT technologies which is applied in modern classrooms. Thus, the main goal of our research is to consider the possibilities and benefits of implementing existing IoT technologies in Computer Science classes.

The development of IoT has brought to smart education, where classrooms are equipped with smart technologies such as big data, IoT and Cloud Computing, which in turn resulted to smart learning with integrated innovative hardware and software, network and storage concepts to provide interactive education environment for all [1].

The term “Internet of Things” (IoT) was first composed in 1999 at a presentation to Proctor & Gamble by Kevin Ashton, the founder of the Massachusetts Institute of Technology’s Automatic Recognition Lab. He pioneered RFID (used in barcode detectors) technology in the field of supply chain management [2]. The first IoT device was created in 1990 by John Romkey when he connected a toaster to a computer system. Remote control became a breakthrough because kitchen appliances could work autonomously with the necessary programming.

The field of the Internet of Things was considered by domestic and foreign researchers works’. In particular, D.I.Muromtsev, V.N.Shmatkov [3]; Quanyan Zhu, Tausifa Jan Saleem, Mohammad Ahsan Chishti, Zaramenskih E.P., Artemyev I.E. [4],[5].

Xiaoyang Zhong and Yao Liang in their article "Raspberry Pi: An Effective Vehicle in Teaching the IoT" focus on the utilization of Raspberry Pi as a teaching tool for the Internet of Things (IoT) to enhance students’ learning performance and experience [6]. In the article “Your Phone as a Sensor: Making IoT Accessible for Novice Programmers” the authors D. Jean, B. Broll, G. Stein and Á. Lédeczi presents PhoneIoT, a mobile application designed to instruct beginners in the fundamental principles of distributed computation and networked sensing. This app enables novices to learn the basics of these concepts effectively [7]. All these scientific researches were the basis for the formation of the importance of IoT technologies in the life of education, principles of implementation of smart technologies, and general theoretical foundations.

Basic provisions. In today's educational landscape, building digital competencies is increasingly recognized as essential for student success in a technologically advanced society. The advent of the Internet of Things (IoT) offers significant opportunities to improve educational practice and develop these competencies. This study makes clear several key points that highlight the transformative potential of IoT technologies in education.

Integration of Internet of Things technologies into educational systems is considered the most important factor in increasing the digital competencies of students. IoT devices and interconnected systems in classrooms and laboratories provide students with essential hands-on experience while immersing them in cutting-edge technology environments. This exposure promotes a comprehensive understanding of digital concepts and the development of essential technical skills. By using these technologies, students can move from theoretical knowledge to practical application, thereby improving their overall learning experience.

In addition, Internet technologies influence the improvement of students' practical skills. These technologies provide experiential learning to provide count data in a timely manner and in an interactive environment. By interacting directly with digital tools, students improve their technical abilities and develop critical problem-solving skills, analytical thinking, and sustainability management skills. The research shows that such skills are critical to effectively navigating an increasingly digital landscape, ensuring students are well prepared for the demands of the modern workforce.

Additionally, the adaptability of IoT solutions allows for the creation of personalized learning experiences tailored to the unique needs and learning styles of individual students. Through continuous data collection and analysis, educators can personalize teaching methods to optimize student engagement and performance. This personalized approach ensures that each student receives the support and resources they need to effectively develop their digital competencies. It highlights the role of the

Internet of Things in promoting differentiated learning, thereby catering to diverse student populations and their learning preferences.

Thus, the points made in this study highlight the transformative potential of IoT technologies in education. They emphasize the need for their strategic integration to effectively prepare students for the challenges and opportunities of the digital age. By developing core digital competencies, students will be better prepared for future success, ensuring they can make a positive contribution to a rapidly evolving technological society.

Materials and Methods. Recent research is dedicated to exploring the opportunities of IoT that can be used to solve challenges faced by students in the education process and teachers in effectively using the benefits of the Internet of Things. The research approach will commence with a broad review of existing literature that covers scholarly articles, reports, and studies that investigate successful applications and tools of IoT in education. This literature analysis aims to develop a rudimentary understanding of the current situation and identify key trends and challenges. Subsequently, the study will conduct a systematic examination of real-world examples and case studies where IoT devices have demonstrated remarkable success in enhancing the educational experience.

Ultimately, this comprehensive research methodology, integrating literature review, real-world case studies, and hands-on experiments aims to deliver a sophisticated understanding of the effective use of IoT devices and technologies in the education sector. Through this multifaceted approach, the study seeks to contribute valuable insights that can inform educators and technologists in optimising the integration of IoT for enhanced educational outcomes.

Results and discussion. Our analysis highlighted several themes and patterns that are related to the IoT in Education. One of the main themes is the potential of IoT to simplify personalised learning experiences, where students have a choice to learn at their own pace and receive appropriate feedback according to their level and preferences. Moreover, IoT encourages active engagement in students and practical learning, contributing to collaboration, creativity and critical thinking.

One of the main aims of the use of the Internet of Things in education is to improve the digital competencies of students through engagement. The term “digital competence” was first introduced in 1997 by the American journalist and writer Paul Gilster (Gilster, 1997). According to Gilster, the constant presence of information in the hypertext field forms new forms of behaviour, and new ways of searching, connected with the possibility of fast movement between sources. At the same time, this leads to the formation of the so-called network thinking, one of the main characteristics of which is high informational and communicative activity. “Digital competence is the set of knowledge, skills, attitudes, abilities, strategies and awareness that are needed to use ICT and digital media to accomplish tasks; solve problems; communicate; manage information; cooperate; create and share content; and to accumulate knowledge effectively, efficiently, appropriately, critically, creatively, flexibly, ethically, reflectively for work, leisure participation, learning and communication.” [8]. Gilster notes the following skills as an example of reaching digital competence: “communication with others, skills of finding necessary information and tools to process it, ability to perceive information expressed in various semiotic systems.” Teaching strategies need changes as well as the competencies teachers need to develop to be able to bring up compatible 21st-century learners. The Framework of DigCompEdu results from a series of discussions and decisions with experts and practitioners, based on a literature review and synthesis of existing documents and tools at the European and international level. The Framework identifies 6 different areas in which a teacher’s digital competence is mentioned among 22 competencies, represented in Figure 1.

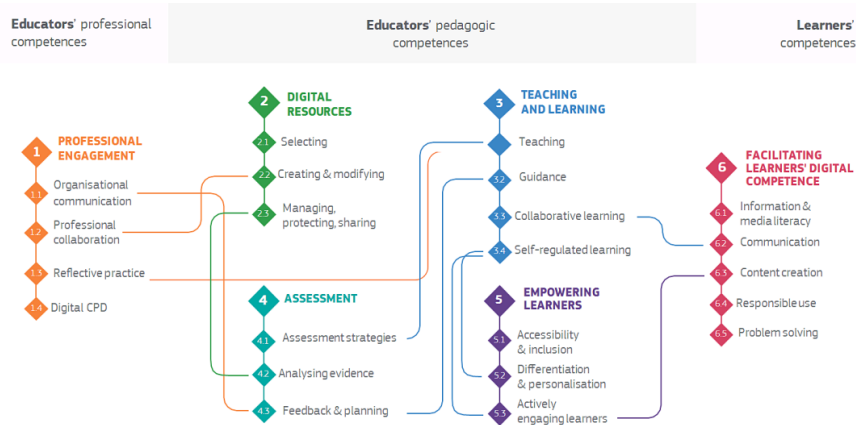


Fig 1. Synthesis of the DigCompEdu framework

The Framework emphasizes the pedagogical and methodological elements particular to the teaching process (competency areas 2–5). While competency areas 2 through 4 elaborate on the digital skills necessary for teachers to design, execute, and assess teaching and learning activities, competency area 5 elaborates on the digital skills required for teachers to prioritize students' involvement in those activities.

IoT architecture is based on four layers as shown in Figure 2. The physical layer is considered the first layer and includes components such as radio frequency identification tags (RFID) tags, sensors, and actuators. They are usually wired or wireless and serve to gather information, they may be wired and wireless. The next layer is the network layer which connects wired and wireless networks and the cloud. Then comes the software layer that serves to process the data gathered. It represents databases, data processing units, and powerful data processing servers for data processing. Therefore, the processing layer facilitates the communication protocol necessary for managing and transmitting data, thereby allowing an IoT application or tool to function. The application layer comes last, it provides machine-to-human, and machine-to-machine interaction using smart devices. Eventually, IoT helps people to collect information, analyse data and take corresponding action.

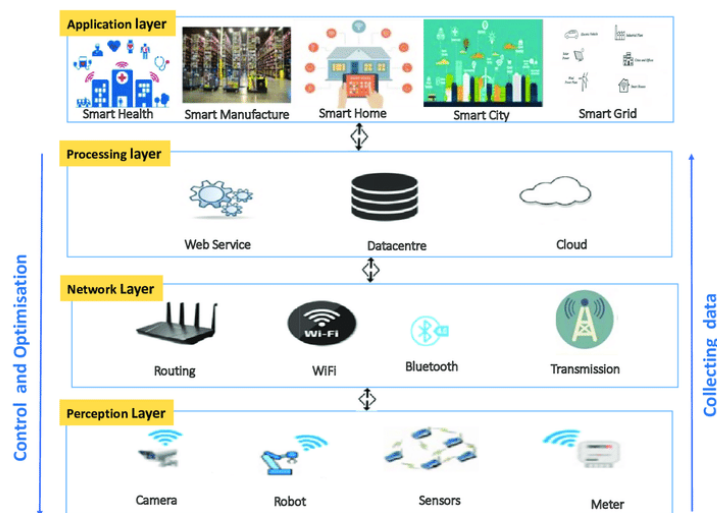


Fig 2. IoT architecture

A. IoT in Education: Smart School

The education sector stands to benefit greatly from the effective integration of IoT technology. Research indicates that IoT offers a wide array of applications within education, benefiting teachers, students, and school administrators alike. In this section, we provide an overview of potential IoT applications in school environments as outlined in existing literature. While the idea of smart schools,

driven by ICT, is not new, it remains in its early stages of development. This section aims to explore how IoT implementation can contribute to the realisation of the smart school concept.

A. IoT for smart school management

Energy management. An energy management system implies all the strategies that are used to minimize energy usage during ongoing operations. Energy management impacts both organizational and technical protocols, as well as behavioural norms, to decrease overall operational energy consumption, optimise the use of primary and supplementary resources, and consistently enhance the university's energy efficiency [9]. School organisations can potentially save hundreds of dollars each month by improving the smart utilization of energy resources. By simply organising electrical energy by demand, schools can save significant amounts of money. To efficiently conserve energy, it is crucial to oversee energy usage to pinpoint areas where energy is being wasted. Monitoring energy consumption involves observing energy usage trends over time and pinpointing wasteful energy practices. Subsequently, upon completion of energy monitoring, effective strategies for conserving energy can be put into action to reduce overall energy usage.

School Security. IoT is a powerful tool in terms of school security. The majority of schools lack security infrastructure that can identify abuse, theft, and other accidents that may occur within the school. For security purposes, authors propose IoT solutions specially designed for schools to organise smart security settings. The system provides a secure alert mechanism that simplifies the users at school [10].

Management of students with special needs. Users may experience a variety of discomfort or disability during school time. IoT is widely used to meet the needs and requirements of such users. For example, researchers have developed a tool that has the function of remembering activities and potentially lost items. They offer IoT-based solutions to assist the daily activities of an adult with ADHD (Attention Deficit Hyperactivity Disorder). It is a neuro-biological disorder of the brain and is characterised by inattention, anxiety and impulsivity. IoT can also be used with people with autism, a neurodevelopmental disorder that affects a person's communication and behaviour. The smart system uses a computer, the internet and sensors to connect with the computer of a child. The system then provides in-depth real-time information to therapists, and caregivers about the movement of a child using sensors. IoT also facilitates the lives of people with sensory difficulties. A wearable device can serve as a tool that demonstrates images of action going around, when the doorbell rings, an image of a guest is sent.

Smart School Transport. Students' transportation can be managed by IoT solutions. M. V. Vyavahare offers an IoT-based vehicle-monitoring system [11]. The system uses a mobile phone application and a microcontroller where the position of the bus is defined by GPS. Parents in turn can monitor the movement of the bus.

Students Health Monitoring System. IoT systems allow physicians to keep an eye on their patients remotely and schedule their appointments more efficiently. Treatments that are not mandatory to be taken at hospitals may be switched to homes. Researchers built an IoT-based health-monitoring system utilizing Arduino to measure a patient's BT, HR, and SpO2 [12]. The system uses Bluetooth to transmit data to the app. Another research work's direction is to detect emotions using Long Short-Term Memory (LSTM). The IoT framework was proposed for healthcare and distance learning during the pandemic era.

B. IoT for Teachers

Attendance System. Using the manual attendance method not only consumes a significant amount of time but also poses a serious risk of losing crucial data. The fundamental components of the RFID system include RFID tags, readers, a backend storage system, and a central section housing all the electrical components. Students can remotely access their attendance data, they can log in and review it at a later time [13].

Feedback and assessment system. Assessment tools based on IoT offer easy methods to evaluate student performance, focusing on factors such as engagement, interaction, participation, and task

completion. Researchers offered an application of E-Learning Motivation Systems (E-LMS) that monitors and tracks student performance [14].

IoT for STEM. IoT integration in STEM education enhances hands-on learning experiences by enabling students to interact with real-world data and devices, fostering a deeper understanding of technological concepts. Researchers have developed IoT-based smart environments to better understand Physics and Programming. The application called Edu-talk allows users to build science projects that include 3D and learn physics [15].

C. IoT for learners

Personalized Learning Experience. IoT technologies enable the collection of large amounts of data about student interactions and preferences. By leveraging this data through analytics and machine learning algorithms, teachers can personalize the learning experience according to the needs and learning styles of individual students. For example, IoT-enabled learning platforms can track student progress, identify strengths and weaknesses, and adapt learning content and pace accordingly. This personalized approach leads to better learning outcomes, increased participation and motivation.

Collaborative Learning Opportunities. IoT fosters collaboration among students by facilitating the creation of interconnected learning environments. With shared access to IoT devices and data, students can collaborate on projects, conduct experiments, and solve problems collectively. For example, a group of students interested in robotics can collaborate to design, build, and program IoT-enabled robots to perform specific tasks. This collaborative approach encourages the skills, teamwork, communication and peer learning essential to success in the digital age.

The field of Computer Science is a natural fit for the integration of Internet of Things (IoT) technologies due to its emphasis on computational thinking, problem solving, and innovation. The table 1 explores variations how IoT can be effectively incorporated into Computer Science classes to improve learning outcomes and prepare students for the evolving technology landscape.

Table 1. Publications between 2020 and 2024 with integrating IoT in Computer Science classes

Author(s) of Research	Year	Research Approach	Inventions / Findings / Results
Aleš Jaklič	2020	Introduction to computer science and engineering by building Internet of things devices	A successful case for using NodeMCU open source platform hardware and software platform in a pre-engineering STEM workshops
L. Huraj; M. Host'ovecký	2020	The Fibaro Starter Kit with sensors for the case study and its applicability to three different CS subjects	Increased students' interest in IoT issues and develop their understanding of the overall concept of the Internet of Things.
Liu et al.	2021	An IoT-based wisdom education platform	The proposed platform's testing findings demonstrate its viability and demonstrate that it has high throughput, low application latency, and good practicability while being able to efficiently monitor classroom use.
Ahmed A et al.	2022	Integrating IoT Technologies into the CS Curriculum	The modules developed have been used to introduce a new project-based course in the CS department at PVAMU that focuses on intelligent IoT technologies
Anatolij Fandrich et al.	2022	A smart-environments learning kit	The kit allows projects without using Node-RED and any textual programming, and removes the described entry barriers of the predecessor.
Mahapatra et al.	2023	The IoT-based gamified educational method	The suggested educational strategy makes use of field techniques and the gamification of course modules in an IoT environment for enhancing learning stages.

Conclusion. Integrating IoT technologies into educational settings can significantly enhance the learning experience by providing learners with hands-on, real-world applications of theoretical concepts. In this article, we've explored the myriad ways IoT can enrich the educational experience, develop digital competencies, and prepare students for the challenges of the digital age.

Digital competencies encompass a wide range of skills, knowledge and attitudes needed to navigate the complexities of today's interconnected world. From technical proficiency in programming and data analysis to critical thinking, collaboration, and ethical reasoning, digital competencies are fundamental to success in academic and professional pursuits. Using IoT technologies, teachers can develop digital competencies among students in different ways. Through hands-on learning opportunities, students engage in real-world applications of theoretical concepts, hone problem-solving skills, and gain practical insights into complex phenomena. A personalized learning experience tailored to individual needs and preferences promotes autonomy and agency, allowing students to take ownership of their learning journey.

In addition, IoT facilitates collaboration and communication among students, fosters a culture of teamwork and peer learning. By working on collaborative IoT projects, students not only improve their technical skills, but also develop the interpersonal and communication skills essential to succeed in a digital society. Additionally, IoT education bridges the gap between theory and practice by providing students with hands-on experiences that deepen their understanding of abstract concepts and theories. By interacting with IoT devices and systems, students gain practical skills and insights that go beyond traditional classroom learning, preparing them for the dynamic and ever-evolving landscape of technology.

In conclusion, the integration of IoT technologies holds great promise for enhancing digital competencies and transforming educational practices. Using IoT-based pedagogies and practices, educators can empower students to thrive in an interconnected and digital world, arming them with the skills, knowledge, and attitudes needed to succeed in the 21st century and beyond. As we continue to explore the possibilities of IoT in education, let us be vigilant in our quest to create an equitable, inclusive, and ethical educational environment that empowers students to reach their full potential.

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БОЛАШАҚ ПЕДАГОГ-ПСИХОЛОГТАРДЫҢ ЦИФРЛЫҚ ЭТИКЕТІН ЖЕТІЛДІРУДІҢ МАҢЫЗЫ

Аңдатпа

Мақалада болашақ педагог-психологтарды дайындауда цифрлық этикет дағдыларын жетілдіру мәселелері қарастырылған. Білім беру кеңістігінде цифрлық қарым-қатынаста этикалық ережелерді зерделеу мәселесі, оның ішінде жоғары оқу орны білім алушылары арасында цифрлық этикет дағдыларын қалыптастыруға арналған зерттеулер көп қамтылмаған. Мақалада цифрлық этикетті жетілдіру болашақ педагог-психологтардың кәсіби құзыретінің бір бөлігі ретінде қарастырылады.

Заманауи цифрлық қоғам жағдайында педагогтардың цифрлық сауаттылығы мен цифрлық этикетті игеруінің қажеттілігі көрсетіледі. Авторлар цифрлық ортада кәсіби іс-әрекетке дайын педагог кадрларды даярлаудың өзектілігін қарастырып, білім беру үдерісіндегі цифрландырудың негізгі қарама-қайшылықтарын сипаттайды. ЖОО-ның цифрлық білім беру кеңістігінде оқытушылар мен студенттер арасындағы тиімді қарым-қатынас орнатудың рөлі айқындалып, цифрлық қарым-қатынас этикетінің маңыздылығы негізделді.

Болашақ педагог-психологтардың цифрлық этикет түсінігіне деген қатынасын анықтау үшін авторлық сауалнама жүргізіліп, оның нәтижесі ұсынылған. Сауалнамаға қатысушы білім алушылардың басым бөлігі цифрлық этикетке қызығушылық танытқанымен, олардың бұл саладағы дағдылары жеткілікті түрде дамымағаны, виртуалды қарым-қатынаста цифрлық этикетті сақтамайтындығы, цифрлық кеңістікте моральдық мінез-құлықтық әрекеттерді сақтау соншалықты маңызды деп ойламайтындығы атап өтіледі. Авторлар болашақ педагог-психологтардың цифрлық этикетін жетілдіру бойынша цифрлық этикетті элективті курс ретінде немесе бір пәннің модулі ретінде кірістіруді ұсынады.

Түйін сөздер: цифрлық этикет, цифрлық кеңістік, білім беруді цифрландыру, виртуалды қарым-қатынас.

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ВАЖНОСТЬ СОВЕРШЕНСТВОВАНИЯ ЦИФРОВОГО ЭТИКЕТА БУДУЩИХ ПЕДАГОГОВ-ПСИХОЛОГОВ

Аннотация

В статье рассматриваются вопросы совершенствования навыков цифрового этикета в подготовке будущих педагогов-психологов. Отмечается, что изучение этических правил цифрового общения в образовательном пространстве, в том числе исследования, направленные на формирование навыков цифрового этикета среди студентов вузов, в настоящее время освещено недостаточно. В статье совершенствование цифрового этикета рассматривается как часть профессиональной компетентности будущих педагогов-психологов.

В условиях современного цифрового общества подчеркивается необходимость освоения педагогами цифровой грамотности и цифрового этикета. Авторы рассматривают актуальность подготовки педагогических кадров к профессиональной деятельности в цифровой среде, описывая основные противоречия процесса цифровизации образования. Раскрывается роль установления эффективного взаимодействия между преподавателями и студентами в цифровом образовательном пространстве вузов, обосновывается значимость цифрового этикета в коммуникации.