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INTEGRATION OF INTERNET OF THINGS TECHNOLOGIES INTO EDUCATION AND PROSPECTS OF THEIR APPLICATION IN KAZAKHSTAN

Abstract

In modern education, the Internet of Things (IoT) technologies are considered a promising tool for creating adaptive and intelligent learning environments. However, current research in this field mainly focuses on the development of smart classrooms, automated attendance control, and campus security. Most studies emphasize technical aspects or limited implementation cases, which do not provide a comprehensive understanding of IoT's potential in education. The aim of the article is to examine the experience of integrating IoT technologies into educational processes in different countries, analyze successful practices and approaches, and identify the potential of IoT for improving the quality of education. The study includes a comparative analysis of international practices as well as a survey conducted among lecturers and students of Abai Kazakh National Pedagogical University. Based on the collected data, practical recommendations for the creation of intelligent learning spaces are proposed, including automation, monitoring, and personalized learning.

Keywords: IoT technologies in education, smart classroom, personalization of learning, digitalization of education, intelligent learning environment, monitoring of academic performance, automation of processes, management of educational resources.

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ЗАТТАР ИНТЕРНЕТИ ТЕХНОЛОГИЯЛАРЫН БІЛІМ БЕРУГЕ ИНТЕГРАЦИЯЛАУ ЖӘНЕ ОЛАРДЫ ҚАЗАҚСТАНДА ҚОЛДАНУ ПЕРСПЕКТИВАЛАРЫ

Аңдатпа

Қазіргі білім беруде Заттар интернеті (IoT) технологиялары бейімделген және зияткерлік оқу орталарын құрудың болашағы зор құралы ретінде қарастырылады. Алайда осы саладағы зерттеулер негізінен ақылды сыныптарды әзірлеуге, қатысуды автоматтандырылған бақылауға және кампусты қауіпсіздікті қамтамасыз етуге бағытталған. Олардың көпшілігі техникалық аспектілерге немесе шектеулі енгізу жағдайларына назар аударады, бұл IoT-тің білім берудегі мүмкіндіктерін тұтас түсінуге мүмкіндік бермейді. Мақаланың мақсаты – әртүрлі елдердің білім беру үдерістеріне IoT технологияларын енгізу тәжірибесін зерделеу, табысты тәжірибелер мен тәсілдерді талдау, сондай-ақ білім сапасын арттырудағы IoT әлеуетін айқындау. Жұмыста халықаралық тәжірибелерге салыстырмалы талдау жасалып, Абай атындағы Қазақ ұлттық педагогикалық университетінің оқытушылары мен студенттері арасында сауалнама жүргізілді. Алынған деректер негізінде интеллектуалды оқу кеңістіктерін құруға арналған практикалық ұсынымдар берілді, оған автоматтандыру, мониторинг және оқытуды жекелендіру кіреді.

Түйін сөздер: IoT-білім берудегі технологиялар, ақылды сынып, оқытуды жекелендіру, білім беруді цифрландыру, зияткерлік оқу ортасы, үлгерім мониторингі, процестерді автоматтандыру, білім беру ресурстарын басқару.

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ИНТЕГРАЦИЯ ТЕХНОЛОГИЙ ИНТЕРНЕТА ВЕЩЕЙ В ОБРАЗОВАНИЕ И ПЕРСПЕКТИВЫ ИХ ПРИМЕНЕНИЯ В КАЗАХСТАНЕ

Аннотация

В современном образовании технологии Интернета вещей (IoT) рассматриваются как перспективный инструмент для создания адаптивных и интеллектуальных учебных сред. Однако исследования в данной области в основном направлены на разработку «умных» классов, автоматизированный контроль посещаемости и обеспечение безопасности на кампусе. Большинство из них сосредоточено на технических аспектах или ограниченных условиях внедрения, что не позволяет получить целостное представление о возможностях применения IoT в образовании. Цель статьи – изучить опыт внедрения технологий IoT в образовательные процессы различных стран, проанализировать успешные практики и подходы, а также определить потенциал IoT в повышении качества образования. В работе проведен сравнительный анализ международного опыта и организован опрос среди преподавателей и студентов Казахского национального педагогического университета имени Абая. На основе полученных данных представлены практические рекомендации по созданию интеллектуальных учебных пространств, включающие автоматизацию, мониторинг и персонализацию обучения.

Ключевые слова: IoT-технологии в образовании, умный класс, персонализация обучения, цифровизация образования, интеллектуальная учебная среда, мониторинг успеваемости, автоматизация процессов, управление образовательными ресурсами.

Introduction

The Internet of Things (IoT) plays a key role in the digital transformation of various fields, including education. The introduction of IoT technologies into the educational process is becoming necessary to meet the requirements of the modern economy, which requires graduates to have not only basic knowledge, but also digital literacy, skills in working with innovative technologies and adaptability to changing conditions.

One of the reasons for the relevance of the topic is the increasing need for personalization of the educational process. Traditional teaching methods often do not take into account the individual characteristics of students, their level of education and preferred style of perception of information. IoT provides opportunities for adaptive learning, so that educational programs can be individually customized for each student. For example, the use of smart devices and sensors allows us to collect data on students' activity, success, and learning difficulties, which gives teachers the opportunity to adjust the educational process in a timely manner.

In addition, IoT technologies contribute to the creation of smart classrooms and campuses, which increases the comfort and efficiency of learning. Smart whiteboards, automated control of lighting, temperature and noise levels in classrooms not only improve the conditions for classes, but also save resources of educational institutions. Issues of sustainable development, including energy conservation, are becoming particularly relevant in the context of global environmental challenges, and IoT contributes to their solution.

Another aspect of relevance is the need to integrate IoT into STEAM education. Educational programs in science, technology, engineering, and mathematics require practical knowledge and skills to work with modern devices. Using IoT in laboratory classes allows students to master working with sensors, microcontrollers and other devices, developing their technical competencies. This is especially important for training specialists in the fields of engineering, computer science and robotics.

The introduction of IoT in education also contributes to the development of an interdisciplinary approach. IoT brings together technologies from different fields such as computer science, mathematics, physics and biology, giving students the opportunity to master knowledge at the

intersection of sciences. This approach meets modern requirements for learning, focused on solving complex problems.

The introduction of Internet of Things (IoT) technologies into the educational sphere of Kazakhstan is a strategic priority and part of state policy, which is emphasized in the National Project «Technological Breakthrough through Digitalization, Science and Innovation» for 2021-2025 [1]. Support for IoT technologies is also enshrined in the Concept of Digital Transformation for 2023-2029 [2] and in the Law of the Republic of Kazakhstan dated May 21, 2024 № 86-VIII, which create the legal basis for the modernization of educational infrastructure [3].

However, Kazakhstan faces a number of challenges on its way to «smart schools and universities.» The main ones are the insufficient training of teachers to work with IoT, the lack of necessary technical infrastructure and the high costs of implementing these technologies. Solving these issues requires an integrated approach and the study of successful international experience.

The purpose of this article is to study the experience of implementing IoT in educational processes in different countries, analyze successful practices and identify the potential of IoT to improve the quality of education and create innovative learning environments.

As a result of the research, practical recommendations have been developed for creating intelligent learning spaces based on IoT, which include:

- creating smart classrooms with automated management of resources such as lighting, temperature, and humidity;
- automation of student performance and attendance monitoring systems;
- personalization of the educational process based on data analysis;
- ensuring safety and optimizing the use of the learning space.

The implementation of these measures contributes to improving the quality of education, expanding access to digital resources and training specialists in demand on the labor market.

The Internet of Things (IoT) is the concept of a network of objects equipped with technologies to interact with each other over the Internet. This technology turns ordinary objects into part of a single system that collects and analyzes data using sensors [4]. In education, IoT is a powerful tool for improving the quality of education, creating an intelligent environment, and improving the digital literacy of future professionals.

Smart education is the effective and purposeful use of ICT (information and communication technologies) to achieve educational results. The main focus is on the personalization of learning and the development of digital competencies of students [5].

Nevertheless, the introduction of IoT is associated with certain risks, in particular, cybersecurity and data privacy issues [6]. Possible threats include leakage of personal data of students and teachers, unauthorized access to educational resources, and attacks on IoT devices. Therefore, when implementing IoT, it is necessary to ensure a high level of information protection and prevent potential threats.

International experience confirms that IoT is a powerful tool for modernizing education. The integration of IoT into educational processes brings significant benefits. For example, in China, the use of an IoT-based voice assistant in higher education demonstrates how sensor devices and wireless networks help monitor the learning environment (temperature, humidity, light). Such a system provides convenience in managing learning conditions and allows teachers and students to easily interact with devices, which increases the comfort and effectiveness of learning. This highlights the importance of creating an interactive educational environment, which also promotes the development of independence and time management among students [7].

In India, IoT technologies are actively used to automate educational processes. For example, the Saveetha School of Engineering uses systems for classroom management, monitoring student attendance, and analyzing student activity through sensors and mobile applications. Smart learning spaces are also being created, where IoT devices provide lighting and climate control, which increases student comfort and engagement. These approaches make the educational environment more modern

and effective, contributing to the transformation of educational processes and improving the quality of education in the country [8].

In the United States, Internet of Things (IoT) technologies are being actively introduced into educational institutions to create smart classrooms and effectively manage campuses. IoT systems allow you to monitor environmental parameters such as temperature, light and humidity, which creates comfortable conditions for the learning process. Automation of campus management, including regulation of lighting and heating, helps to reduce energy consumption and increase energy efficiency. IoT is also used to manage educational resources, which optimizes the distribution of equipment and materials. An important aspect is the personalization of learning: data on student behavior helps to adapt the learning process and create customized curricula, which increases student engagement. Thus, the introduction of IoT in the educational sphere of the United States contributes to improving the interaction between teachers and students and increases the overall effectiveness of the educational process [9]. One of the leading universities actively implementing IoT solutions are Carnegie Mellon University (USA, Pennsylvania, Pittsburgh) and Arizona State University (USA, Arizona, Tempe).

As part of various projects, Carnegie Mellon University (USA) actively uses IoT to optimize the learning environment and improve educational processes. For example, classroom conditions (temperature, light conditions) are monitored through IoT systems, which helps to improve comfort for students and teachers. In addition, the university implements systems for automating educational processes and managing educational resources. IoT projects integrate sensor devices and real-time data to create a personalized educational experience, allowing learning to be tailored to the needs of each student. This highlights the importance of integrating modern technologies into the educational process and promotes the training of specialists who are able to work effectively with such innovations. Thus, IoT is being used to create «smart classrooms and campuses», which has an impact on improving the quality of education and managing the learning environment [10], [11].

Carnegie Mellon University (CMU) has developed an IoT system for monitoring and controlling equipment in scientific laboratories. Sensors installed on spectrometers, centrifuges, and microscopes collect data on their use, transmitting it to the central control system. This makes it possible to optimize the availability of equipment, prevent overloading and minimize downtime, which is especially important for research laboratories with limited equipment resources. CMU is one of the leading universities in the field of robotics, artificial intelligence and IoT, which makes it a center for innovative solutions in education.

At Arizona State University (ASU), IoT technologies are actively used to ensure the safety of students and create a comfortable educational environment. The University has implemented a system of sensors and cameras that collect real-time data on temperature, noise level, air quality and congestion. This data is analyzed to quickly identify potential threats such as overcrowding, ventilation problems, or congestion on campus roads. ASU is also known for its innovations in digital education and the integration of IoT into the campus infrastructure.

The experience of these universities demonstrates the versatility of IoT in education, ensuring not only the rational use of equipment and resources, but also increasing the level of comfort and safety of students. These examples can serve as a model for the implementation of similar solutions at universities in other countries, including Kazakhstan, as part of the development of the «smart campus» concept and the digitalization of the educational environment.

Bangladesh is exploring the impact of IoT on various sectors of the economy, including education. IoT technologies have demonstrated their potential in the context of the COVID-19 pandemic, contributing to the optimization of educational processes and helping to overcome the difficulties associated with remote learning and limited access to educational resources. They allowed for effective interaction between teachers and students, even at a distance [12].

In some countries, such as China, medical education programs using IoT technologies are actively developing, which also highlights the diversity of applications of these technologies in different fields.

Japan is actively implementing Internet of Things (IoT) technologies in the educational process, striving to modernize the learning system and increase the level of digital literacy of students. One of the key projects aimed at the digital transformation of education is the GIGA School government program, which has been implementing IoT and smart technologies in schools in the country since 2019 (Japan Times, 2021). As part of the GIGA School, each student receives a personal device (tablet or laptop) connected to a cloud-based learning management system. This provides access to digital resources and allows you to personalize the learning process (Trade.gov, 2023). Schools are equipped with smart boards, lighting and temperature sensors, as well as automated control systems that create comfortable learning conditions. For example, in the city of Kawachinagano, IoT solutions for classroom monitoring were introduced, which made it possible to increase the convenience of the educational process (Panduit, 2023). Thanks to high-speed Internet and cloud technologies, Japanese schools are integrating IoT into learning management systems (LMS), allowing teachers to monitor student performance in real time (MEXT, 2020). The GIGA School uses artificial intelligence (AI) technologies to analyze student learning data. This allows you to adapt training materials and identify knowledge gaps by offering personalized recommendations.

Robots are also being developed in Japanese schools to help with learning and interaction with students. Activity sensors are also used to analyze student behavior and identify problem areas in the educational process (Japan Times, 2021). The GIGA School program has already demonstrated high efficiency:

- improving students' digital skills;
- increasing learning flexibility through distance learning technologies;
- creating smart classrooms that adapt to the individual needs of students;
- resource savings through IoT control of lighting, ventilation, and educational materials.

The Japanese experience shows that the integration of IoT into education contributes to the formation of a digital educational environment, increases student engagement and makes the learning process more interactive.

IoT can enhance the effectiveness of college and university education by making students feel more at ease and involved, improving exam results and providing opportunities for professional growth. Teachers also benefit from IoT technology as they can find resources for lectures, send online assessments with automatic corrections, and have online meetings with parents.

The research [13] examines the experience of implementing IoT in education in Italy. The study is based on the example of the Italian Engineering Institute of Higher Education, where an IoT educational laboratory was developed to train students in accordance with the requirements of Industry 4.0. The main focus is on teaching students how to work with IoT infrastructure, analyze sensor data and integrate it into cyber-physical systems. In the course of their experiment, key areas of IoT use in the educational process were implemented, including:

- the development and deployment of IoT infrastructure,
- the integration of cyber-physical systems (CPS),
- the use of cloud technologies for data processing,
- the use of a hybrid learning approach, including theoretical online courses and practical work with IoT devices.

An analysis of the results showed that the students who completed this program demonstrated a higher level of practical skills in working with IoT, which is confirmed by an assessment of their competencies based on Bloom's taxonomy. The introduction of a hybrid learning system has helped to increase student engagement and improve learning. The data obtained indicate that the integration of IoT into the educational process contributes to the development of students' professional skills necessary to work in the context of Industry 4.0.

This experience confirms that educational programs that include IoT labs and a digital environment can significantly improve the quality of training specialists in technical areas and adapt students to the modern challenges of digital transformation.

Research shows that Internet of Things (IoT) technologies are becoming increasingly in demand in education around the world. Many works emphasize that IoT contributes to improving the effectiveness of learning and improving interaction between all participants in the educational process. According to Baniki et al. (2017), IoT technology has transformed traditional educational systems into more adaptive and responsive to dynamic change, enabling students to learn quickly and effectively through problem solving, personal management, and video and game learning approaches [14]. However, teachers need to integrate these new teaching and learning methods into their practice, encouraging collaboration, active learning, and closer communication between teachers and students.

The use of IoT in education brings many advantages. Students can instantly interact with learning materials and receive feedback, which contributes to a deeper understanding of the material. Teachers can monitor students' progress in real time, which allows them to identify problems in a timely manner and provide the necessary support. The data collected through the IoT helps course developers adapt curricula and create new materials that meet the needs of students. Despite the many advantages of implementing IoT in educational institutions, there are a number of problems and challenges. Integrating different technologies and ensuring their compatibility can be challenging tasks for educational institutions. Protecting students' and teachers' personal information from cyber threats is an important issue that requires attention. The need to train teachers and administrative staff to use new technologies can become a significant barrier to the successful implementation of IoT.

Thus, the potential of IoT in education is huge, but its implementation requires in-depth research and an integrated approach that takes into account both the advantages of the technology and the problems that arise during its implementation. Further research will allow us to develop optimal strategies to achieve maximum effect.

Research methodology

For this review, publications from the Scopus and Web of Science databases for the period from 2016 to 2025 were used. The search was conducted using the keywords: «*Internet of Things in education*», «*smart classrooms*», «*IoT for learning environment*». The review includes works in English, Russian and Kazakh, which allowed taking into account both the international and local context.

The criteria for the selection of publications were:

- practical application of IoT technologies in an educational environment;
- research related to the impact of IoT on the educational process and its results;
- papers describing the challenges and limitations of implementing IoT in education.

Articles that focus solely on the technical aspects of IoT without reference to the educational environment are excluded.

The analysis of the publications allowed us to systematize knowledge about the use of IoT in education and identify three key areas of research:

- the technical basis of IoT in an educational environment (description of IoT infrastructure);
- the pedagogical basis (effectiveness of IoT in education): the study of the impact of IoT on student motivation, learning quality, and collaboration between students and teachers;
- and related challenges and obstacles to widespread adoption, such as lack of funding, cybersecurity issues, and resistance to change on the part of teachers.

Despite certain difficulties with access to some sources of information, the conducted research, based on an analysis of available publications, allowed us to identify key areas and trends in the introduction of IoT into the educational system of Kazakhstan, to gain a more complete understanding of the specifics of their implementation.

Results of the study

The analysis of the publications confirms that the topic of the introduction of the Internet of Things in education is relevant to the global community. Rich international experience is a fundamental basis for their successful integration into Kazakhstani educational institutions. In the context of the digital

transformation of education, their introduction into the educational environment is becoming particularly important.

Kazakhstani universities are actively involved in this work, one of them is the Department of Informatics and Informatization of Education at KazNPU Abai, where a scientific project is being successfully implemented, the purpose of which is not only to introduce IoT into the educational process and create a «smart classroom», but also to train a new generation of specialists capable of working in the created intellectual educational environment. use these technologies in the field of education and teach them to schoolchildren. In order to determine the need for the introduction of IoT into the system of training future teachers, the creation of a smart educational environment equipped with smart equipment, its potential advantages over the traditional learning environment and the requirements for its functionality, this study examined and analyzed the above-mentioned work of scientists and the results of implemented practices in this area, as well as conducted a survey among 216 respondents (students of the specialty «Informatics», «Informatics and robotics» and «Information systems in education», as well as faculty of the department). In order to identify the most in-demand functions of the «smart educational environment» and form appropriate requirements for its functionality, respondents were asked 10 questions (Table 1) concerning key aspects of the educational environment equipped with smart devices and related equipment. The data obtained will optimize the functionality of the created environment, increasing its convenience and efficiency, in accordance with the actual user requirements.

Table 1. Questions on the identification of key aspects of the functionality of the intellectual educational environment and the results of the survey on them

№	Questions	No	I don't know	Yes
1	The presence of automation systems for regulating the microclimate and lighting in the classroom improves comfort and increases productivity	4 (2%)	22 (10%)	190 (88%)
2	The technological equipment of the educational environment contributes to the academic performance of students	26 (12%)	17 (8%)	173 (80%)
Evaluate whether the following intelligent features of the environment are important:				
3	The possibility of remote access to educational materials and equipment in the classroom	22 (10%)	43 (20%)	151 (70%)
4	The convenience of managing a smart educational environment	-	54 (25%)	162 (75%)
5	Ensuring the security and confidentiality of students' personal data used in a smart educational environment, including academic performance	4 (2%)	52 (24%)	160 (74%)
6	An intelligent assistant (based on AI) that helps students find the information they need and answer questions.	10 (4.5%)	12 (5.5%)	194 (90%)
7	The presence of an adaptive learning system that adjusts the complexity of tasks to the student's level of knowledge.	2 (1%)	15 (7%)	199 (92%)
8	Automated attendance monitoring system	22 (10%)	17 (8%)	177 (82%)
9	The system of automatic accounting of current academic performance	30 (14%)	7 (3%)	179 (83%)
10	The function of recording lectures and automatically saving them to cloud storage	17 (8%)	130 (60%)	69 (32%)

In this questionnaire, the Likert scale 3 was used (1-«no», 2-«I don't know», 3-«yes»). Teachers and students evaluated her in accordance with their real ideas and expectations, which turned out to be similar in many ways.

The survey results provided a more complete picture of the needs and expectations of various user groups and highlighted the main requirements for its functionality:

- combining computers, an interactive panel, audio and video systems, touch tables and other classroom equipment into a single system (with sensors for light, temperature, motion, etc.) used in a «smart home»;

- integration of the above-mentioned technical devices and classroom equipment with other university information systems and popular educational platforms (LMS, Microsoft Teams, etc.) to optimize the learning process;

- combining interactive equipment (interactive panels, surveys, tests, and other classroom tools) into a single system to involve students in the learning process and ensure active interaction between the subjects of the educational process;

- automation of routine classroom-specific processes: automatic monitoring of student attendance, automatic task verification, and automatic control of technical equipment (just like in a smart home);

- personalization of learning: adaptation of educational materials and teaching methods to the individual needs of each student;

- automating the recording and storage of lectures to view them again and create a knowledge base;

- automating the processes of collecting and analyzing data on attendance, class performance, and student preferences to optimize the learning process;

- ensuring user-friendliness: a simple and intuitive interface for managing all classroom systems that were taken into account when creating a Smart Classroom at KazNPU Abai.

The integration of the Internet of Things into education and the creation of an innovative educational environment based on them opens up unique opportunities for innovation and improvement of the quality of education. However, the realization of these opportunities is fraught with certain difficulties that must be taken into account.

The initial costs of creating an IoT infrastructure can be substantial, but they are a prerequisite for obtaining long-term benefits, such as improving the effectiveness of the educational process, providing conditions for personalized learning, and improving interaction between teachers and students in an intelligent learning environment.

At the same time, the introduction of IoT in education entails new challenges related to cybersecurity. Among the most common risks are:

- the possibility of leakage of personal data of students and teachers;

- unauthorized access to educational resources;

- attacks on IoT devices used in the educational process;

- the possibility of using IoT devices for surveillance or manipulation;

- distribution of malicious software. Connected devices can be used to spread viruses within the institution's network;

- privacy violation: Data collection and analysis by IoT devices may be misused or made available to third parties.

To minimize cyber threats, it is necessary to apply an integrated approach that includes the following measures:

- implementation of modern data encryption protocols to protect information;

- using multi-factor authentication and access monitoring systems;

- regular software updates of IoT devices to eliminate vulnerabilities;

- conducting regular security audits and implementing training programs for staff and students on cybersecurity.

Along with the above, for the successful implementation and effective use of Internet of Things technologies in the educational process, it is necessary to ensure the availability of competent personnel. In this regard, it is proposed to implement the following measures:

- development and implementation of new academic disciplines dedicated to IoT and digital technologies in educational programs for future teachers;
- organization of seminars and advanced training courses for teachers and technical staff on working with IoT devices, setting up infrastructure and ensuring security;
- creation of competence centers and laboratories equipped with IoT devices for the study and application of IoT in education;
- developing partnerships with technology companies to share experiences and knowledge.

These measures will ensure a high level of professionalism among the staff of educational institutions and guarantee the effective use of IoT in the educational process.

Discussion

The data obtained during the survey clearly indicates a high demand for the modernization of the educational process in Kazakhstan using IoT technologies. The overwhelming majority of respondents (over 90%) support the introduction of adaptive learning systems and intelligent assistants, which indicates the urgent need to personalize education and move away from the traditional «one for all» model. The request to create an interactive and automated environment where routine tasks such as monitoring attendance and academic performance are performed automatically is fully consistent with global trends. The successful experience of the United States in creating «smart campuses» and the Japanese GIGA School program for equipping schools with intelligent technologies confirms that Kazakhstan's expectations are in line with global educational practices.

Thus, the study not only confirms the relevance of IoT implementation, but also opens up prospects for further work. The key areas for future research should be:

- development of comprehensive cybersecurity measures to protect data in the educational environment.
- creation of new pedagogical techniques that effectively use the technological potential of «smart classrooms».
- assessment of economic efficiency and development of scalable models for the widespread adoption of IoT in educational institutions of the country.

Conclusion

The integration of Internet of Things technologies into the educational process opens up a wide range of opportunities to improve the quality and effectiveness of learning. IoT promotes the creation of smart classrooms, the introduction of personalized learning methods, as well as the optimization of educational resources. These innovations meet the requirements of digital transformation and contribute to the training of specialists with in-demand digital skills.

However, the introduction of IoT into the educational environment involves a number of challenges, such as significant financial costs, cybersecurity risks, and the need to train qualified personnel. To overcome them, it is important to apply an integrated approach, including attracting grant funding, developing interdisciplinary cooperation and implementing pilot projects. Successful examples of international practice demonstrate that IoT integration can significantly improve educational processes and management of educational institutions.

The recommendations proposed in the article can be used to develop strategies for implementing IoT in educational institutions. They will help to minimize challenges and use the potential of technology to create a modern educational environment. Thus, IoT is becoming an important tool for the formation of competitive specialists and ensuring the sustainable development of the education system.

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