

INTEGRATION OF DIGITAL TECHNOLOGIES IN THE TRAINING OF SPECIALISTS IN THE FIELD OF GEODESY, LAND MANAGEMENT AND URBAN PLANNING

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Abstract. The article investigates the impact of digital technologies on the specialists training in the field of geodesy, land management and urban planning. The methods of introducing geographic information systems (GIS), remote sensing and automated data processing into the educational process are considered. The practical skills that students acquire through the use of new technologies are analyzed, as well as the adaptation of curricula to the requirements of the modern labor market to increase the competitiveness of graduates.

Keywords: digital technologies, geographic information systems (GIS), remote sensing, data processing automation, training, geodesy, land management, urban planning, professional skills, innovative technologies.

The modern development of information technology is fundamentally changing approaches to education in various fields, including geodesy, land management and urban planning. The use of digital technologies is becoming an integral part of training, as they provide fast and accurate data processing, reduce time and resources, and increase the efficiency of spatial planning and land management processes. The integration of digital tools into the educational process allows not only to improve students' knowledge and skills, but also to adapt them to the real needs of the labor market, where more and more attention is paid to automation and digital transformation of work processes. Modern educational theories state that skills should be acquired through active research, in which teachers facilitate student learning [1].

In the context of globalization and rapid changes taking place in the engineering and geoinformation fields, training qualified specialists requires the introduction of innovative teaching methods. This includes the use of GIS (geographic information systems), BIM (building information modeling), drones for geodata collection, automated land management systems, and other technologies that contribute to an integrated approach to spatial object management. This approach not only ensures quality education but also creates conditions for the active participation of future professionals in the processes of sustainable development of cities and territories, infrastructure development, and support for environmentally sound resource use.

A geographic information system (GIS) is software that processes digital geospatial data, allowing users to store, visualize, and analyze spatial information [2]. Studies show a positive relationship between the introduction of GIS-based learning and student engagement in the learning process [3]. For example, several student research projects have used GIS to

visualize data on noxious weeds, dead trees, security issues, and natural disasters [4]. The use of GIS in geological fieldwork allowed students to more easily understand the connections between geological structures compared to conventional teaching [5]. As a result of using GIS, students' spatial thinking and reasoning skills improved [6]. Geographic research skills are an important component of the Chinese secondary geography curriculum. However, in most secondary schools in China, the learning process remains traditional and emphasizes rote learning rather than hands-on exploration, especially in the context of geospatial technologies, as it is also seen in South Africa [7].

Current research on this topic emphasizes the need to integrate digital technologies into the educational process, including geographic information systems (GIS), remote sensing, and automated data processing tools. This contributes not only to improving students' practical skills but also to adapting to the requirements of the modern labor market, where more and more attention is paid to working with large data sets and digital maps. For example, the development of geodata in curricula is aimed at developing skills in territory modeling and urban planning, which is important for increasing the competitiveness of graduates. In addition, the authors of this study emphasize the importance of involving students in geoinformatics at an early stage of education to increase their interest and prepare them for choosing geoinformation disciplines in the future. Successful STEM programs show that early exposure to the subject increases students' interest in continuing their education [8].

Another key challenge is to adapt the curricula to modern market conditions, which includes preparing specialists to work in the context of the digital transformation of the economy and changes in legislation. This includes the integration of new

technologies, such as global navigation satellite systems (GNSS) and unmanned aerial vehicles (drones), which are critical for geodetic and land management work.

For example, in 2022, the Korean Ministry of Education revised the national curriculum with a focus on students' digital skills [9]. The secondary school subject of Korean Geography was transformed into a career-oriented discipline to help students with their professional development [10]. The study confirms that the use of geographic information technologies (GST) and new digital competencies meets the requirements of vocational education set by the Ministry [11].

The author of the article, Mary Farger, suggests using WebGIS not only as a tool for analyzing spatial data, but also for building powerful disciplinary knowledge (PDK). She considers the importance of an approach that emphasizes the use of geography knowledge and the development of spatial thinking skills. The study also presents a "curricular artifact" (learning object) built in ESRI ArcGIS Online based on the 2004 Indian Ocean tsunami, which demonstrates how integrating WebGIS into learning can develop an understanding of key geographic concepts such as space, place, and interconnection [12].

He, Wei & Chen, Mingze study the application of innovative technologies and artificial intelligence (AI) in urban design and planning. They analyze how AI, digital tools, and geodesy are transforming the modern urban environment, making it more sustainable, efficient, and convenient. The authors explore the functionality of technologies such as machine learning, neural networks, and other approaches used to predict trends, make decisions, and automate complex geospatial tasks [8].

The article by Wang, Chuanbing & Yang, Daihu & Xu, Huimin explores the implementation of a geographic information system (GIS) to explore the relationships between geographic elements and housing prices in school geography. Using data on apartment prices in Hefei, China, the authors developed GIS activities that help students better understand how different urban elements such as government offices, schools, hospitals, and roads affect price formation. The analysis showed that apartments closer to these facilities have a higher price. Students who had never worked with GIS before were given the opportunity to learn mapping and spatial data analysis skills. Students noted that the new approach made geography lessons more interesting, and GIS allowed them to move from passive learning to active research, providing more opportunities for self-study. It is noted that GIS tools have significantly increased students' interest, allowed them to visualize the relationships between elements of the urban structure and improved understanding of geographic factors impact on housing prices. However, the authors note the limited availability of equipment and short training time, which made it difficult to master GIS technologies more deeply [9].

However, the integration of digital technologies into education also has its challenges. One of the key barriers

is the insufficient technical base in many educational institutions, which limits students' access to modern digital tools. Many universities and colleges face the problem of lacking the latest equipment, licensed software, and high-speed internet, which is critical for the effective use of technologies such as GIS, remote sensing, UAVs, and BIM. This is especially true for educational institutions in remote regions, where limited funding is becoming a major obstacle to modernizing the educational process.

Moreover, preparing teachers for the introduction of digital technologies requires considerable effort. Not only do they have to learn new tools, but they also have to adapt their teaching methods to use digital solutions in teaching. For example, teachers need to learn how to work with software for creating spatial models, data analysis, and information visualization, which requires additional training, professional development, and advanced training that may not always be available due to limited resources. Many teachers face problems with mastering modern software solutions, which complicates the process of introducing digital technologies into teaching.

Another challenge is the adaptation of students to new teaching methods, as some of them may have difficulty mastering digital tools, which requires more intensive support from teachers. Students who have not previously worked with GIS or other digital technologies often need additional time to master the basics of working with such programs. In particular, beginners may have difficulty analyzing data, developing digital maps and spatial models, which can reduce their motivation to learn and slow down their progress in material learning. To ensure successful adaptation of students, it is important to introduce interactive learning approaches and use more intuitive software solutions.

There is also a cultural barrier associated with changing traditional teaching methods. The shift from passive information perception to active interaction with digital technologies requires a change not only in methods but also in the mindset of students. They have to learn to be more independent, proactive, and capable of independent research, which is not always common in the traditional educational system. This can create additional difficulties for students who are used to a more directive style of learning, where the main role belongs to the teacher.

In addition, there are ethical and legal aspects of integrating digital technologies. The use of digital data, especially when working with GIS and remote sensing, can lead to issues of data privacy and security. Students and teachers need to be aware of data usage legal norms and adhere to ethical standards when working with geospatial information, especially when dealing with personal or sensitive data.

During the COVID-19 period, which has become a real challenge for all areas of education, including the training of specialists in the field of geodesy, land management and urban planning, the integration of

digital technologies into education has become crucial as quarantine restrictions and distance education have become a new reality. Digital technologies have made it possible to continue the educational process, supporting the continuity of learning and providing students with access to the necessary resources, tools and data even when their physical presence is limited.

The COVID-19 pandemic has forced higher education institutions to quickly switch to distance learning, and digital technologies have become the only way to continue training students in geodesy and urban planning. The use of geospatial data processing software (e.g., GIS, AutoCAD, Revit) has become not only an alternative to traditional methods, but also contributed to the expansion of students' competencies in remote analysis and modeling. Digital technologies have become indispensable in providing remote access to educational materials and practical tasks, which made it possible for students to continue their studies without significant losses in the quality of knowledge.

The transition to online platforms and digital tools has opened up new opportunities for more flexible learning. Students are able to access lectures, videos, interactive simulations, and online libraries at any time. Such changes made the learning process more adaptive, which is important for both students and teachers, especially during the pandemic, when the work schedule often changed due to unforeseen circumstances. The integration of digital platforms has allowed educational institutions to quickly adapt their curricula to new conditions, which has become a critical success factor in the pandemic.

The use of digital technologies in the training of specialists during the COVID-19 period has contributed to the development of new skills that have become necessary in the modern digital world. Students not only mastered basic professional competencies but also developed skills in remote collaboration, communication, and problem solving in the online environment. This has become an important aspect of the training, as the labor market has also adapted to new realities, requiring specialists who can work effectively with digital tools in a remote format.

COVID-19 has stimulated the use of international online platforms that have allowed students and teachers to interact with colleagues from other countries, share data and research results. This was made possible by digital platforms that support geodata exchange, remote modeling, and project visualization. The integration of digital technologies into education during the pandemic has created a unique environment for international cooperation and access to the latest scientific developments in the field of geodesy and urban planning.

Moreover, modern digital solutions allow for a quick response to challenges related to infrastructure restoration and rebuilding, damage monitoring, efficient land management, and planning for future reconstruction and development of the affected areas, which is especially relevant for the Ukrainian context. Military operations in Ukraine have caused significant damage to infrastructure, including roads, buildings, bridges, and other facilities. The use of geographic information systems (GIS) and remote sensing (RS) in assessing the extent of damage and creating damage maps is an important tool for quick decision-making in the field of reconstruction. Digital technologies enable the creation of 3D models of damaged facilities, which helps in planning recovery efforts, prioritizing objects for reconstruction, and assessing the need for materials and resources. Digital tools increase the efficiency of geospatial data management, enabling specialists to respond to changes in the field more quickly and accurately.

Modern technologies play a crucial role in the training of specialists in the field of geodesy, land management and urban planning, contributing to more efficient management of territories and natural resources. Growing urbanization, climate change, and the need for sustainable development are driving the introduction of innovative solutions that improve the accuracy of data collection, optimize analysis processes, and allow for modeling future changes in the territory. Digital technologies such as geographic information systems (GIS), remote sensing (RS), LiDAR, blockchain, Internet of Things (IoT), artificial intelligence (AI) and machine learning, 3D modeling and virtual reality (VR), and BIM (building information modeling) are actively used in this area. GIS allows for the creation of interactive maps and terrain models for making land use decisions, while remote sensing technologies use satellite and drone imagery for accurate mapping. Lidar systems enable the creation of three-dimensional terrain models, and blockchain improves the transparency of land registries. IoT helps to monitor the condition of soil and natural resources, while AI automates data processing and predicts landscape changes. 3D modeling and VR technologies help visualize infrastructure projects, while BIM ensures efficient coordination of construction and facility management. All of these technologies not only increase the accuracy and efficiency of specialists' work, but also promote transparency and integration of spatial planning processes. The introduction of digital innovations in geodesy, land management and urban planning not only optimizes workflows, but also creates conditions for more efficient use of resources, sustainable development of territories and improvement of the quality of life in cities and rural areas (Fig. 1).

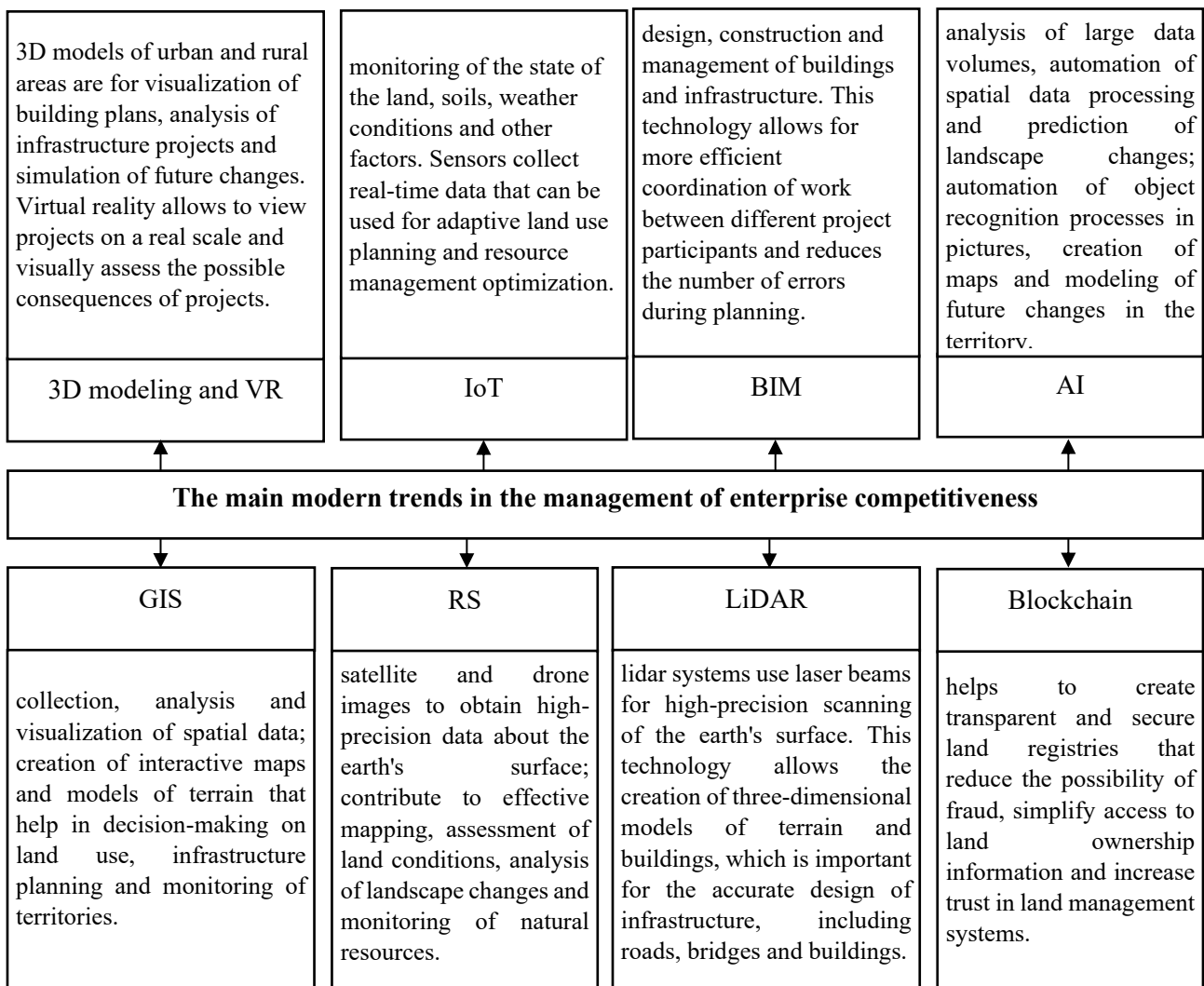


Fig. 1. Digital technologies used in the training of specialists in the field of geodesy, land management and urban planning

Modern information technologies are fundamentally changing approaches to education and work in the field of geodesy, land management and urban planning. They provide fast data processing, reduce resource consumption and increase the efficiency of planning and management of territories. Integration of digital tools into the educational process improves students' knowledge and skills, adapting them to the requirements of the labor market, which is increasingly focused on automation. The use of technologies such as GIS, BIM, drones, LiDAR, blockchain, IoT and artificial intelligence ensures transparency, process optimization and rational use of resources, contributing to sustainable development and improving the quality of life in urban and rural communities.

The strategic task of modern higher education in the context of innovative informatization of society is to accelerate positive changes, provide intellectual resources and scientific developments through the introduction of innovative technologies in all areas of activity, including the management of the educational process. The main goal is to create a comprehensive computer network to ensure quality education, which will allow for the implementation of individualized education in the long term through the use of modern

technologies. The development of university infrastructure is a prerequisite for the effective use of innovations in education, including the introduction of computer equipment, network support, educational terminals and specialized software.

To achieve this goal, higher education institutions should develop a long-term informatization program that will include automation of the educational process management, improving its efficiency and productivity. Such a program should facilitate the integration of feedback into the educational system, ensuring rapid changes in the content and methods of teaching, and optimizing the methodological and technical support for training specialists. The use of cloud technologies allows teachers to store teaching documents in the cloud storage and organize shared access to resources for students and teachers. This contributes to the operational control of student performance and expands the possibilities of managing the educational process, regardless of geographical distance.

Modern educational programs also emphasize the development of practical skills and project work, which allows students not only to master theoretical knowledge but also to participate in real projects, internships, and laboratory research. The development

of distance learning provides access to interactive simulations, online courses, and training materials, making the educational process more flexible and adaptive. Given the complex problems of urbanization, climate change, and land management, training should also focus on an interdisciplinary approach that integrates knowledge of ecology, economics, sociology, and engineering. The use of artificial intelligence and big data analysis allows specialists to solve complex problems, such as predicting landscape changes, automating land management processes, and developing strategies for sustainable development of territories. Global cooperation also plays an important role, facilitating the implementation of international standards and the exchange of experience, in particular through participation in international projects and exchanges. In the context of post-conflict reconstruction, particularly in Ukraine, training should focus on methods of infrastructure reconstruction, damage monitoring, and designing resilient infrastructure.

The integration of digital technologies in the training of specialists in geodesy, land management and urban planning has significant prospects, but requires addressing a number of organizational, technical and social challenges. Despite these obstacles, the successful implementation of digital technologies in the educational process contributes to improving the quality of education and the competitiveness of graduates in the labor market.

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