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Comparative Analysis of the Implementation of Information Technologies in Higher Education Institutions of the Czech Republic and Ukraine

Abstract: This article examines the theoretical and practical aspects of informatization of education as a key factor in improving the effectiveness of the educational process in higher education. The scientific novelty of the study lies in the comprehensive comparative analysis of the implementation of information technologies in higher education institutions of the Czech Republic and Ukraine. The article reveals new aspects of digital transformation in education by comparing institutional, infrastructural, and pedagogical approaches in two European countries with different socio-economic contexts. The originality also consists in identifying three interrelated levels of informatization — physical, logical, and applied — and establishing their influence on the quality of the educational process and digital competence formation. The object of the study is the process of informatizing higher education. The subject of the study is the methods, mechanisms, and results of implementing information technologies in universities of the Czech Republic and Ukraine. The purpose of the study is to determine the role and effectiveness of information technologies in enhancing the quality of higher education, as well as to identify similarities and differences in their implementation within Czech and Ukrainian educational systems. The author concludes that informatization is a strategic direction for educational development, ensuring the formation of a digital culture, enhancing the competence of teachers and students, and integrating them into the global information space.

Keywords: informatization of education, information technology, digitalization, information culture, IT competence, Ukraine, Czech Republic.

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Порівняльний аналіз впровадження інформаційних технологій у вищих навчальних закладах Чехії та України

Анотація: У статті розглядаються теоретичні та практичні аспекти інформатизації освіти як ключового чинника підвищення ефективності навчального процесу у вищій школі. Зазначено,

що сучасний етап розвитку суспільства характеризується стрімкою цифровізацією, яка охоплює всі сфери людської діяльності, зокрема освіту. Визначено три рівні розвитку інформатики — фізичний, логічний і прикладний, — які забезпечують створення цілісної інформаційно-освітньої системи. Проаналізовано етапи інформатизації освіти: комп'ютеризацію, персоналізацію та соціалізацію інформаційних фондів. Окреслено основні напрями застосування інформаційних технологій у навчальному процесі: створення електронних підручників, мультимедійних систем, інтелектуальних експертних систем, електронних бібліотек і засобів телекомунікації. Особливу увагу приділено порівнянню зарубіжного та вітчизняного досвіду цифровізації освіти на прикладі Чехії та України. Виявлено, що Чехія реалізує системну державну політику у сфері цифрової грамотності та має розвинену інфраструктуру, тоді як Україна демонструє динамічний розвиток, але стикається з проблемами фінансування й нерівного доступу до ІТ-ресурсів. Зроблено висновок, що інформатизація є стратегічним напрямом розвитку освіти, який забезпечує формування цифрової культури, підвищення компетентності педагогів і студентів та інтеграцію в глобальний інформаційний простір.

Ключові слова: інформатизація освіти, інформаційні технології, цифровізація, інформаційна культура, ІТ-компетентність, Україна, Чехія.

Introduction

The current stage of societal development is characterized by the rapid computerization of all spheres of human activity, and especially education. Improving the quality of specialist training in higher education largely depends on the integration of computer science advances and new information technologies into the educational process. Researchers note that computer science as a scientific field is considered at three levels: physical (hardware, software, and communications), logical (information technology), and applied (user-level systems). At the same time, computer science tools not only improve teaching methods but also shape the information culture of the younger generation, a prerequisite for entering the "information society".

Researchers' works demonstrate a trend toward a gradual development of the computerization of education: from computerization (the initial saturation with technical means), through personalizing information resources (the widespread adoption of computing technology and the development of computer literacy), to socializing information funds (the creation of integrated databases and the provision of remote access). Another important factor is the development and implementation of educational programs that take into account the specifics of using the latest IT technologies in teaching, research, and education management.

Several scientific papers compare international and domestic experiences in digitalizing education. Specifically, research findings indicate that in the Czech Republic, digital literacy is integrated into national educational standards and actively supported at the state level, while in Ukraine, the process of informatization is dynamic but faces funding challenges and unequal access to infrastructure. Despite these challenges, Ukrainian higher education is gradually adapting to global trends, implementing modern educational platforms, electronic resources, and collaborating with IT companies.

Thus, an analysis of recent publications confirms that informatization is a key factor in improving the effectiveness of the educational process. This encompasses not only technical support but also the development of a digital culture, the development of information competence among teachers and students, and the integration of education into the global

information space.

An analysis of recent research and publications. Improving the quality of higher education specialist training is largely determined by advances in computer science, which are being integrated into the educational process.

Computer science as a scientific field can be considered at three levels:

- Lower (physical) is software and hardware of computing and communications technology;
- Middle (logical) is information technology;
- Upper (intended for the user) is applied information systems.

Computer science tools can also be used to engage the younger generation in information culture, which is becoming increasingly relevant in connection with the transition to an "information society". According to scientists, this transition is planned for 2050 in Ukraine, 2020 in the USA and Japan, and 2030 in the leading countries of Western Europe.

The first stage of informatization has a specific purpose—the computerization of society. The most significant results of this stage in education include the extensive dissemination and initial saturation of the Ukrainian university system with computer technology. However, their current level of equipment is insufficient, averaging 3 to 5 computers per 100 students. This is an order of magnitude lower than in developed countries, and for some US universities, there is one personal computer or one workstation per student (university data). At the same time, this stage marks the formation of the foundations of information culture, as well as the beginning of the computer-based development of existing information resources in education.

The second stage of informatization can be summarized as personalizing information resources, which is associated with the intensive use of computing technology at all levels of education, the conversion of information resources to computer (machine) form, and a sharp increase in computer literacy among young people.

The third stage can be defined as socializing information resources, which will lead to the emergence of a high level of information culture, the creation of integrated computer information resources with remote access, and further development to fully meet the growing information needs of the population.

The scientific novelty of the study lies in the comprehensive comparative analysis of the implementation of information technologies in higher education institutions of the Czech Republic and Ukraine. The article reveals new aspects of digital transformation in education by comparing institutional, infrastructural, and pedagogical approaches in two European countries with different socio-economic contexts. The originality also consists in identifying three interrelated levels of informatization—physical, logical, and applied—and establishing their influence on the quality of the educational process and digital competence formation.

The object of the study is the process of informatizing higher education.

The subject of the study is the methods, mechanisms, and results of implementing information technologies in universities of the Czech Republic and Ukraine.

The purpose of the study is to determine the role and effectiveness of information technologies in enhancing the quality of higher education, as well as to identify similarities and differences in their implementation within Czech and Ukrainian educational systems.

According to the purpose of the study, the main tasks:

- analyse theoretical and methodological foundations of educational informatization;
- study the stages of informatization and their impact on the efficiency of educational processes;
- compare the level of IT implementation in Czech and Ukrainian higher education institutions;
- identify systemic problems and formulate recommendations for improving digital transformation in Ukrainian education based on Czech experience.

Methods

The research employed a complex of general scientific and special methods to ensure the reliability and objectivity of the results.

Among general scientific methods, the study used analysis and synthesis to examine theoretical approaches to informatization and its structural levels; induction and deduction to generalise empirical data and derive conclusions; and system-structural analysis to identify interconnections between technical, pedagogical, and managerial components of digital transformation in education. The comparative method was used to contrast the Czech and Ukrainian experiences of implementing IT in education, revealing their convergent and divergent features.

Among special methods, the study applied content analysis of scientific and statistical reports, educational strategies, and institutional documents of Czech and Ukrainian universities; expert assessment of digital competence development; and classification and modelling to structure the stages of informatization—computerization, personalization, and socialization. Empirical generalisation allowed identification of common trends in e-learning, cloud technologies, and artificial intelligence integration in educational processes. The methodological basis of the research is the systemic approach, which views informatization as a dynamic, multi-level process of socio-technical interaction between educational institutions and the digital environment.

Literature Review

A review of the literature demonstrates that the informatization of education is a multidimensional process encompassing technological, pedagogical, and organisational aspects. According to Ovcharuk (*2020*), digital competence has become a key indicator of professional readiness of teachers within European educational standards. Similarly, Stoika (*2021*) and Kostolanyová et al. (*2023*) emphasise that the Czech educational system systematically integrates digital literacy into curricula through the DigComp and DigCompEdu frameworks.

Holubová and Jansa (*2020*) traced twenty years of e-learning development at Czech universities, confirming the institutional maturity of blended learning models, while Dvorakova (*2022*) showed that digitalization has become an essential component of executive education and lifelong learning in the Czech Republic. In contrast, studies by Voronkin (*2021*) and Popel & Shyshkina (*2018*) highlight that Ukraine is in a transitional phase, with uneven access to IT resources and reliance on cloud and open-access educational platforms such as Moodle and Google Classroom.

Research by Hlásná, Klímová, and Poulová (*2017*) revealed that Czech primary education ensures early development of digital literacy, supported by infrastructure and teacher training. Similar approaches are described in international analyses of ICT integration, showing that the Czech Republic belongs to the group of EU leaders in educational digitalization. Conversely, Ukrainian authors (*Vakaliuk et al., 2020*; *Voronkin, 2021*) underline the rapid but fragmented nature of digital transformation, often driven by donor-funded initiatives.

Thus, the existing body of research confirms the duality of informatization trends: a structured, state-supported digitalization model in the Czech Republic and a dynamically evolving, decentralised model in Ukraine. The comparative analysis presented in this article contributes to bridging this knowledge gap by identifying transferable practices and evaluating their applicability in the Ukrainian context.

Results

A subprogram for developing and implementing information technologies in education, which has been developed in the Department of Economic Cybernetics and Informatics as a step-by-step program, should occupy a special place in the educational informatization program.

It is worth noting that research and teaching staff in higher education have currently developed a significant number of informatics products that are used both in the educational process and in scientific research. Developments in organizational support for higher education management also occupy a special place among these.

With regard to the educational process and scientific research, new information technologies are of fundamental importance.

Unlike traditional educational technologies, information technology focuses on information as both the subject and the outcome.

Therefore, the quality and application of information products developed within this technology are largely determined by the computers used, operating systems, database structure, etc.

Any information technology involves two problems:

1. Solving specific functional problems of the user;

2. Organizing the information processes that support the solution of these problems. Based on their nature, all problems are divided into those formalized and those that are difficult to formalize. For formalized problems, a well-known typical solution sequence includes the formation or selection of a mathematical model, the development of an algorithm and program, and the implementation of calculations. Most subject curricula include such problems, and therefore the use of information technology for these problems is traditional and is widely used and developed today.

Much more common are difficult-to-formalize problems, which include problems that do not have precise mathematical models during formalization and are therefore solved using knowledge representation models such as logical, algorithmic, semantic, and frame-based. These models are used to reduce difficult-to-formalize problems to elementary problems and logically infer a solution. This ultimately leads to the formation of knowledge bases within expert systems and other types of intelligent systems for educational and scientific purposes.

Organizing information processes within the framework of educational information

technologies presupposes the identification of such basic processes as data transfer, processing, organization of storage and accumulation, and the formalization and automation of knowledge.

Improvements in problem-solving methods and information process organization are leading to entirely new information technologies, including the following in relation to education:

1. Computer-based educational programs, including electronic textbooks, simulators, laboratory workshops, and testing systems.
2. Educational systems based on multimedia technologies, built using personal computers, video equipment, and optical disk drives.
3. Intelligent and educational expert systems used in various visual fields.
4. Distributed databases across knowledge areas.
5. Telecommunications, including email, teleconferencing, local and regional communication networks, data exchange networks, and the like.
6. Electronic libraries, distributed and centralized publishing systems.

Specific software and hardware within these technologies are being developed in parallel at different higher education institutions and are often duplicated. However, the main drawback of the current approach to applying computer science advances in education is the lack of scientific and methodological support for the use of new information technologies. The use of computers in education should not preclude the training of specialists in a realistic, visual field. That is, replacing real physical phenomena with mere model representations on a computer screen is not permissible. Requirements for skills, knowledge, and habits in computer science should vary depending on the type of higher education institution, the nature of training, and the specialty. The objective need to improve the effectiveness of education periodically leads to sudden breakthroughs in the use of tools for organizing the work of all participants in educational activities: students, teachers, scientists, and management personnel. These tools, which claim to fundamentally transform centuries-old understandings of the work functions of all participants in the educational process, include various computer and information technology tools and technologies. Undoubtedly, these tools have already had a tremendous impact on traditional educational paradigms, generating promising hopes for the broad possibilities of dramatically improving the quality of education through increasingly automated systems that also boast high speed, operational memory, and long-term memory. The main areas of use of information and computer tools in education encompass four main areas.

Computer technology and informatics as objects of study (*Ovcharuk, 2020*). This area is not directly related to issues of improving the effectiveness of education. However, historically, the emergence of computers in education was associated specifically with the teaching of the fundamentals of computing, first in vocational education and then in general education.

The study of computer technology and informatics, like the study of any other academic discipline or group of disciplines at various levels of education, is directly related to the issue of educational content in general. The presence of a particular subject in the preparation of students in general and vocational education is determined, first and foremost, by the objectively current and future needs of socio-economic and scientific-technical progress, as well as the personal educational needs of those studying. However, despite the importance of the didactic and methodological issues associated with finding ways to effectively study a particular discipline, it is extremely important to justify the very feasibility of including this discipline in the education

system, especially general education, at the border of the natural sciences and humanities, which are overloaded with "traditional" subjects. If a new subject is included in the curriculum, it should clearly define its contribution to the overall objectives of this educational subsystem, which can be enriched and developed through its use. The need to study computer technology and information technology, along with arguments and justifications, is no longer necessary today.

Computers as a means of increasing the effectiveness of teaching (*Popel & Shyshkina, 2018*). It is in this capacity that computers and information technology are viewed as components of the educational system that are not only capable of fundamentally transforming the very understanding of the category "tool" in relation to the educational process, but also significantly impact (presumably, only positively) the entire delivery of components of a given local educational system: the entire content, methods, and organizational forms of instruction, as well as the upbringing and development of students in educational institutions of any profile. These expectations and prospects are then extended to the entire education system, the entire extensive network of educational services, and the entire field of education in its most general sense—as an integral component of any society, fulfilling its most important functions. The computer, therefore, is becoming an exceptionally promising tool, capable of truly ensuring the necessary shifts in the progressive development of humanity, increasing its integrated intellectual power, and intensifying its scientific, technological, and economic activities.

Computers as a means of increasing the effectiveness of research activities in education (*Stoika, 2021*). Modern scientific research, especially interdisciplinary and complex research, can no longer be successful without comprehensive information support. Such support involves searching for sources of the "most current" scientific and educational information, selecting and selectively evaluating this information, storing it, which ensures an appropriate level of classification and free access to it by potential consumers, and, ultimately, the prompt provision of the necessary information to the user upon request. Each stage of the above-mentioned process of information support for scientific research varies significantly and increases in labor intensity. As interdisciplinary information accumulates, it becomes virtually inaccessible to the individual researcher. This conclusion applies to all fields of science, but the field of education, as demonstrated above, is distinguished by its increased multifactorial nature. Almost any research in this area is systemic and comprehensive in nature, regardless of whether it concerns the substantiation of local components of educational systems (goals, content, methods, means, organizational forms), or the development of a long-term policy and strategy for the development of education in general. The information capabilities of computers integrated into extensive information, computer, and telecommunications networks are truly enormous. Therefore, the importance of this direct informatization in education is entirely obvious. The challenge is to ensure that the system of research problems solved using such powerful tools is commensurate with their significance, a syndrome that still exists in science—the embezzlement of resources and energy.

Scientific research in higher education is worth focusing primarily on understanding the functioning of educational sciences, which can reasonably be called educational science, a unique science of sciences.

Computer and informatics as a component of the educational and pedagogical management

system (*Vakaliuk et al., 2020*). This area of informatization is linked to the process of managerial decision-making at all levels of educational activity—from the day-to-day management of an educational institution to the management of an entire region at the federal and regional levels. It is quite obvious that to make optimal management decisions, a wide variety of information is required, both of a background nature about the development trends of the external socio-economic and socio-cultural environment, and of an educational nature itself.

The aforementioned areas are related to each of the four spheres, which directly influence the development of one or the other and, at the same time, are influenced by the corresponding area of computer use in education. These areas include:

1) the socio-economic sphere of society;
2) the philosophical and methodological sphere (referring to the sphere of interdisciplinary scientific knowledge);
3) the scientific and technical sphere;
4) the psychological and pedagogical sphere.

The scientific substantiation of a comprehensive, integrated concept of informatization in education must be based on a substantive interpretation of both the aforementioned four areas and the four spheres of mutual influence, as well as all the connections between them. This task is highly complex and requires an interdisciplinary, systems approach, integrative logic, and conceptual design methodology. Given its complexity and relative novelty, this problem has not yet been solved, but it urgently demands a solution in the near future. The socioeconomic sphere of society essentially predetermines the need for mass computer-based learning and the widespread use of computer technology as a means of increasing the effectiveness of multifaceted educational and pedagogical activities. It is worth assuming that the very emergence of computers is an objective reality, conditioned by the development of society's material and technical infrastructure. Highest demands are constantly placed on the accuracy, speed, and reliability of the various technical systems that are constantly being developed.

Thus, it is precisely the socioeconomic sphere, interested in the proper return on education, that has dictated and continues to dictate the need for the study and use of information technology at all levels of education, including primary education. Among the diverse factors and relationships accompanying the introduction of computer technology into education, the "human-computer" relationship is undoubtedly central. The obvious globality and multifaceted nature of this problem compel us to explore all the multifaceted human-computer relationships within a specific ideological, philosophical paradigm, and philosophical-methodological framework. Such a framework, if it is necessary, will finally materialize. It should provide general guidelines for assessing the problems of computerization. However, there is no need to overemphasize the capabilities of computers. Despite all its artificial intelligence potential, transformations, and achievements, any computer today is simply a means of enhancing the efficiency of human intellectual activity. Moreover, it is, first and foremost, an informational tool, focused (in all the nuances and specificities of highly specialized computers) on serving human needs. How to make this service (in the broad sense) most productive specifically in education is the central question of the entire multifaceted problem of informatization in education.

The fourth area of interaction and mutual influence relative to all areas of computerization

is the psychological and pedagogical sphere. It is this sphere that is closest to educational practice, called upon, capable, and obligated to add practice-oriented technological effectiveness and completeness to all conceptually important socio-economic, philosophical-methodological, and scientific-technical aspects of a holistic ideology of informatization in education, all of which are more or less remote from direct educational activity.

Underestimating this particular sphere, this conceptual direction, can have a negative consequence, not only negating the desire for computer-based information support for educational systems but also directly harming all participants in the educational process, primarily students. Numerous and entirely convincing examples can be cited that confirm the effectiveness of using computers at all stages of the educational process:

- at the stage of presenting educational information;
- during the acquisition of educational material through interactive computer interaction;
- during the review and reinforcement of acquired knowledge (habits, skills);
- during midterm and final assessments and self-monitoring of achieved learning outcomes;
- during the correction of both the learning process itself and its results by improving the dosage of educational material, its classification, systematization, etc.

All these didactic and methodological possibilities are truly irrefutable. Furthermore, it is necessary to consider that the use of rationally designed computer educational programs is essential for considering not only the specifics of the substantive (scientific) information, but also the psychological and pedagogical patterns of assimilation of this information by a specific contingent of students. This allows for the individualization and differentiation of the learning process, infusing it with elements of "educational games" that stimulate cognitive activity and independence in those learning. Computer-based learning is truly effective, facilitating the implementation of guiding didactic principles for organizing the educational process, infusing teachers' work with fundamentally new content, and enabling them to focus on key learning, educational, and developmental functions.

We will analyze the level of implementation of computer technologies in education.

1. Primary and Secondary Education

In the Czech Republic, digital literacy is an integral part of the curriculum—it is based on the European Digcomp framework, and is assessed through national digital competency tests. The government actively invests in school technology, including computers, stable internet, and interactive whiteboards. Popular platforms include Moodle, Bakaláři, Microsoft 365, and Google Workspace. Students begin learning programming in middle school (Scratch, Python).

In Ukraine, digital literacy is also included in the curriculum, but its implementation often depends on the specific school. Material and technical resources are provided primarily through local budgets or parental contributions. The main educational platforms are the All-Ukrainian Online School, Google Classroom, and Zoom. Programming is typically taught as an elective or at Stem Schools. Systematic assessment of IT competencies is currently in the pilot phase (for example, the IT Fitness Test).

2. Higher Education

The Czech Republic offers over 20 IT programs with a strong applied foundation, extensive practical training, and internship opportunities at Avast, IBM, and Seznam.cz. Education is free

for foreigners and is taught in Czech (English-language programs require a fee). Universities use their own LMS integrated with international systems, and students have access to VR/AR, AI, and cloud services.

In Ukraine, the range of IT specialties is also broad, but training is more focused on theoretical preparation. Foreigners mostly study on a fee-paying basis, in Ukrainian or English. Universities collaborate with IT companies such as Softserve, EPAM, and Genesis. Moodle, Google Classroom, and local platforms are used for training. Access to modern technologies is uneven and depends on the resources of each institution.

3. Teacher Training

In the Czech Republic, digital literacy courses are mandatory, and teachers are certified according to the Digcompedu standard. The state funds professional development and provides access to resources through Edu.cz, Dumy.cz, and methodological portals.

In Ukraine, teacher training in digital competence is primarily voluntary and is implemented through online platforms such as Edera, Prometheus, Edcamp, and the All-Ukrainian Online School. State support is partial, and most initiatives are grant- or donor-funded.

4. Government Initiatives

The Czech Republic is implementing a large-scale national program, "Digital Czech Republic 2030", aimed at developing digital infrastructure, equal access to technology, and supporting edtech startups. The state is actively promoting the implementation of AI in education.

Ukraine is integrating the digitalization of education into the strategy of the Ministry of Education and Science. Edtech support is provided through grants and international partnerships. However, the level of technical support in schools varies significantly between regions, especially in rural areas.

Discussion

The discussion of results indicates that informatization in higher education operates as both a technological and cultural transformation. The comparison between the Czech Republic and Ukraine shows that the success of digital transformation depends on systemic governmental support, sustainable infrastructure, and continuous professional development of teachers. In the Czech Republic, the implementation of the national programme Digital Czech Republic 2030 ensures strategic coordination, investment in digital infrastructure, and integration of artificial intelligence in education. Ukrainian initiatives, while progressive, remain fragmented due to limited funding and unequal regional access.

The study highlights that informatization should be viewed not only as technical modernization but as a holistic pedagogical innovation that transforms teaching methodologies, promotes interactive learning, and builds digital culture among students and educators. Moreover, the results confirm that digital tools—such as electronic libraries, LMS platforms, and multimedia environments—enhance accessibility and inclusiveness of education. However, the lack of unified methodological support and standardisation in Ukraine hinders large-scale adoption.

Thus, sustainable informatization requires a systemic approach that combines infrastructure development, teacher training, and pedagogical adaptation to new digital realities, as successfully

demonstrated in the Czech model.

Conclusion

The conducted comparative analysis confirms that informatization of higher education is a key factor in improving its quality and competitiveness. The Czech Republic's experience proves that consistent government policy, integration of digital standards, and support for educators' competence ensure the formation of a digital academic ecosystem. In Ukraine, the rapid development of online education, cooperation with IT companies, and the spread of cloud platforms demonstrate strong potential for growth, provided adequate financial and methodological support.

In conclusion, informatization must be recognised as a strategic direction of educational policy, fostering digital culture, increasing IT competence, and integrating national education systems into the global information space. The author's contribution lies in the identification of specific mechanisms and best practices of Czech educational digitalization that can be adapted for Ukraine's modernisation strategy.

Conflict of Interest

The author declares that there is no conflict of interest.

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