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THE POTENTIAL OF THE DIGITAL EDUCATIONAL ENVIRONMENT OF A HIGHER EDUCATION INSTITUTION IN PREPARING FUTURE MASTER'S STUDENTS IN SOFTWARE ENGINEERING FOR INNOVATIVE ACTIVITY

Abstract. The article highlights the issue of preparing future Master's students in Software Engineering for innovative activity in the context of the digital transformation of education. The significance of the digital educational environment of a higher education institution as a factor in the modernization of professional training is substantiated, as it ensures the integration of modern digital technologies, innovative pedagogical approaches, and practice-oriented learning.

The purpose of the article is to substantiate the potential of the digital educational environment of a higher education institution and to determine its functional capabilities in preparing future Master's students in Software Engineering for innovative activity.

Research methods: theoretical methods – analysis, synthesis, comparison, generalization, and systematization of scientific literature; structural-functional analysis – to determine the functions of the digital educational environment; modelling and generalization – to develop the author's matrix for implementing the potential of the digital educational environment of a higher education institution.

Scientific novelty of the study lies in clarifying the essence of the concept of the "potential of the digital educational environment of a higher education institution" as an integral characteristic of the digital ecosystem that reflects the set of technological, pedagogical, informational, communicative, and innovative capabilities for preparing future Master's students in Software Engineering for innovative activity. The main functions of the digital educational environment (educational, innovative, integrative, adaptive, and prognostic) have been identified, the peculiarities of their implementation under the conditions of the digital transformation of education have been characterized, and the author's matrix for implementing the potential of the digital educational environment has been developed. This matrix reflects the relationship between its functions, implementation tools, and the expected outcomes of professional training.

Practical significance of the obtained results lies in the possibility of using the proposed theoretical provisions and the author's matrix in the modernization of educational and professional programmes for training Master's students in Software Engineering, the design of the digital educational environment of higher education institutions, the development of educational and methodological support for educational components, and the implementation of innovative digital technologies, artificial intelligence technologies, cloud services, and project-based learning in the educational process.

Keywords: digital educational environment, digital transformation, innovative activity, future Master's students in Software Engineering, digital technologies, professional training, higher education institutions.

ПОТЕНЦІАЛ ЦИФРОВОГО ОСВІТНЬОГО СЕРЕДОВИЩА ЗВО У ПІДГОТОВЦІ МАЙБУТНІХ МАГІСТРІВ З ІНЖЕНЕРІЇ ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ ДО ІННОВАЦІЙНОЇ ДІЯЛЬНОСТІ

Анотація. У статті актуалізовано проблему підготовки майбутніх магістрів з інженерії програмного забезпечення до інноваційної діяльності в умовах цифрової трансформації освіти. Обґрунтовано значення цифрового освітнього

середовища закладу вищої освіти як чинника модернізації професійної підготовки, що забезпечує інтеграцію сучасних цифрових технологій, інноваційних педагогічних підходів і практико орієнтованого навчання.

Мета статті полягає в обґрунтуванні потенціалу цифрового освітнього середовища закладу вищої освіти та визначенні його функціональних можливостей у підготовці майбутніх магістрів з інженерії програмного забезпечення до інноваційної діяльності.

Методи дослідження: теоретичні – аналіз, синтез, порівняння, узагальнення та систематизація наукової літератури; структурно-функціональний аналіз – для визначення функцій цифрового освітнього середовища; моделювання та узагальнення – для розроблення авторської матриці реалізації потенціалу цифрового освітнього середовища ЗВО.

Наукова новизна дослідження полягає в уточненні сутності поняття «потенціал цифрового освітнього середовища закладу вищої освіти» як інтегральної характеристики цифрової екосистеми, що відображає сукупність технологічних, педагогічних, інформаційних, комунікаційних та інноваційних можливостей щодо підготовки майбутніх магістрів з інженерії програмного забезпечення до інноваційної діяльності. Визначено основні функції цифрового освітнього середовища (освітню, інноваційну, інтеграційну, адаптивну та прогностичну), охарактеризовано особливості їх реалізації в умовах цифрової трансформації освіти, розроблено авторську матрицю реалізації потенціалу цифрового освітнього середовища, яка відображає взаємозв'язок між його функціями, засобами реалізації та очікуваними результатами професійної підготовки.

Практичне значення одержаних результатів полягає у можливості використання запропонованих теоретичних положень, авторської матриці під час модернізації освітньо-професійних програм підготовки магістрів з інженерії програмного забезпечення, проєктування цифрового освітнього середовища закладів вищої освіти, розроблення навчально-методичного забезпечення освітніх компонентів, упровадження інноваційних цифрових технологій, технологій штучного інтелекту, хмарних сервісів і проєктно-орієнтованого навчання в освітній процес.

Ключові слова: цифрове освітнє середовище, цифрова трансформація, інноваційна діяльність, майбутні магістри з інженерії програмного забезпечення, цифрові технології, професійна підготовка, заклади вищої освіти.

INTRODUCTION

The problem formulation. In the context of the digital transformation of society, the rapid development of information and communication technologies, the widespread adoption of artificial intelligence technologies, and the modernization of the higher education system, the issue of preparing future Master's students in Software Engineering who are capable of innovative activity, developing digital software products, and rapidly adapting to the dynamic changes of the digital economy has become increasingly relevant.

The Ministry of Education and Science of Ukraine defines the digital transformation of education as a systemic process of developing a modern digital ecosystem that encompasses the creation of a secure digital educational environment, digital infrastructure, the implementation of innovative digital services, the development of digital competence among participants in the educational process, and the automation of educational and managerial processes (Digital Transformation of Education and Science). As practice demonstrates, the modern labour market requires highly qualified specialists who possess not only professional knowledge and skills in software engineering but also the ability for critical and creative thinking, teamwork, project-based activity, continuous professional development, and the implementation of innovations. At the same time, the implementation of these requirements in the higher education system is accompanied by a number of challenges that give rise to contradictions between: the increasing demands of the IT labour market for specialists capable of innovative activity and the insufficient use of the potential of the digital educational environment of higher education institutions; the rapid development of digital technologies and their insufficient integration into the professional training of future Master's students in Software Engineering; the considerable potential of the digital educational environment and the insufficient theoretical substantiation of its implementation in the professional training of future Master's students in Software Engineering.

In our opinion, addressing these contradictions is directly related to the effective utilization of the potential of the digital educational environment of a higher education institution as a strategic resource for professional training, ensuring the integration of digital technologies, educational innovations, and practice-oriented learning, thereby creating conditions for developing the readiness of future Master's students in Software Engineering for innovative activity in the context of the digital transformation of society.

Analysis of recent research and publications. An analysis of scientific studies indicates that the issue of the digital transformation of higher education and the development of the digital educational environment of higher education institutions is one of the priority areas of pedagogical research. The issues of the formation and development of the digital educational environment of higher education institutions have been examined in the works of Ukrainian scholars V. Bykov and O. Burov (Bykov, V., Burov, O., 2021, pp. 11–22), L. Kartashova and T. Burlaienko (Kartashova, L. A., Burlaienko, T. I., 2026, pp. 212–221), A. Striuk (Striuk, A. M., 2023, pp. 168–186), O. Tsiuniak (Tsiuniak, O. P., 2021) and others.

The issues of the digital transformation of universities, the use of digital infrastructure to support innovative activity, and the implementation of modern educational technologies have also been investigated by foreign researchers, including S. Malcolm, D. Steen, and D. Battersby (Malcolm, S., Steen, D., Battersby, D., 2025), as well as M. Ferrari, S. Allan, C. Arnold, D. Eleftheriadis, M. Ɓlvarez-Jimйnez, A. I. Gumley, and J. F. Gleeson (Ferrari, M., et al., 2022). These researchers substantiate the theoretical and methodological foundations for creating a digital educational environment, identify its functional capabilities, structural components, and pedagogical potential, and demonstrate that the effective integration of digital technologies contributes to improving the quality of professional training,

developing digital competence, innovative thinking, and the readiness of higher education students for activity in the context of the digital transformation of society.

Despite the considerable number of scientific studies devoted to the use of digital technologies in professional training and the development of digital competencies, the potential of the digital educational environment of a higher education institution as a factor in preparing future Master's students in Software Engineering for innovative activity remains insufficiently investigated.

THE AIM AND RESEARCH TASKS

The aim of the study is to substantiate the potential of the digital educational environment and to determine its functional capabilities in preparing future Master's students in Software Engineering for innovative activity.

RESEARCH METHODS

Theoretical methods – analysis, synthesis, comparison, generalization, and systematization of scientific literature and regulatory documents; structural-functional analysis – to determine the functions of the digital educational environment; modelling and generalization – to develop the author's matrix for implementing the potential of the digital educational environment of a higher education institution.

RESULTS OF THE RESEARCH

Currently, the digital transformation of higher education has become one of the key priorities of the national educational policy and the institutional development of universities. Under these conditions, the priority task of higher education institutions is to create a digital educational environment that not only provides access to modern digital resources and technologies but also promotes the development of an innovative educational space in which educational, research, project-based, and practical activities are integrated.

In the international scientific literature, the digital educational environment is increasingly viewed as a strategic resource for preparing competitive professionals. In particular, S. Malcolm, D. Steen, and D. Battersby consider the university as a digital ecosystem that integrates digital infrastructure, educational platforms, information services, analytical tools, artificial intelligence technologies, and all participants in the educational process into a unified digital space. According to the researchers, such integration ensures the interaction of educational, research, and managerial activities, enhances the university's adaptability to technological changes, promotes the development of an innovation culture, and fosters the readiness of higher education students for professional activity in the context of digitalization. The researchers emphasize that the digital ecosystem is an important factor in the development of higher education institutions, provides personalized learning, supports interdisciplinary interaction and project-based activity, and creates favourable conditions for the development of professional and innovative competencies of future specialists (Malcolm, S., Steen, D., Battersby, D., 2025).

A group of authors (M. Ferrari, S. Allan, C. Arnold, D. Eleftheriadis, M. Ɓlvarez-Jimйnez, A. Gumley, and J. Gleeson) investigates the effectiveness of digital interventions used in the university environment to support students' psychological well-being. The scholars demonstrate that digital platforms, mobile applications, online programmes, and other digital services create conditions for a more personalized educational environment. The researchers emphasize that digital technologies should be regarded as an integral component of the university ecosystem, which provides student support, contributes to successful learning, and improves the quality of the educational process (Ferrari, M., et al., 2022).

The issues related to the development of the digital educational environment also occupy an important place in the research of Ukrainian scholars. In particular, O. Tsiuniak considers the digital educational environment as an integrated system of digital resources, services, technologies, and pedagogical conditions that ensures effective interaction among all participants in the educational process, promotes the development of digital competence, readiness for lifelong learning, creative problem-solving in professional activities, and innovative activity (Tsiuniak, O., 2021). L. Kartashova and T. Burlaienko argue that the digital educational environment of a higher education institution is a holistic, multi-component system that integrates digital infrastructure, information resources, software and technological tools, digital services, and pedagogical technologies to ensure effective interaction among all participants in the educational process. In particular, they include learning management systems (LMS): platforms for distance learning (Moodle, Google Classroom, Blackboard); digital learning resources: electronic textbooks, video lectures, interactive tasks, simulation models, and other educational materials available in digital format; communication and collaboration tools: means for synchronous and asynchronous interaction (BigBlueButton, Zoom, Microsoft Teams), chats, and forums that facilitate information exchange, question posing, and collaborative work among participants in the educational process; analytical tools: systems designed for collecting, processing, and analysing data on the dynamics of the educational process; mobile applications: tools that provide learners with remote access to educational materials and assignments via personal mobile devices. The scholars emphasize that such an environment should be based on the principles of openness, adaptability, security, and student-centredness, ensuring personalized learning, the development of digital competencies, support for innovative activity, and the improvement of the quality of higher education (Kartashova, L., Burlaienko, T., 2026, pp. 212–221). According to O. Semenoh and O. Tsiuniak, one of the priority directions of the digital transformation of universities is the systematic implementation of artificial intelligence technologies based on international standards and internal institutional policies. The authors argue that this approach contributes to the development of the digital educational environment, the improvement of the educational process, the formation of digital culture, and the readiness of higher education students for innovative professional activity (Semenoh, O., Tsiuniak, O., 2026, pp. 198–208).

The scientific works of O. Hudovsek and N. Kandyba substantiate that the effectiveness of the digital educational environment is ensured by a set of pedagogical conditions, among which the integration of digital services into the educational process, the development of media competence, and the use of innovative educational strategies are of particular importance (Hudovsek, O., Kandyba, N., 2025, pp. 84–88). Sharing the authors' position, we believe that the implementation of these conditions is an important prerequisite for preparing future Master's students in Software Engineering for innovative activity. According to V. Bykov and O. Burov, the digital learning environment creates the prerequisites for the transition to a new model of professional training, in which the learner acts as an active participant in the educational process, capable of effectively using digital technologies to solve professional tasks (Bykov, V., Burov, O., 2021, pp. 11–22).

Of particular scientific interest are the works of A. Striuk, who argues that the use of cloud-based learning tools in the training of Software Engineering specialists ensures the mobility of the educational process, supports project-based learning, promotes the development of professional competencies, and brings educational activities closer to the real conditions of the modern IT industry. The author emphasizes that the integration of cloud technologies influences not only the technological component of education but also the content of the professional training of future software engineers (Striuk, A., 2023, pp. 168–186).

The generalization of scientific approaches presented in the works of international and Ukrainian scholars provides grounds for asserting that the potential of the digital educational environment of a higher education institution is an integral characteristic of the digital ecosystem that reflects the totality of technological, pedagogical, informational, communicative, and innovative resources and capabilities aimed at ensuring high-quality professional training of future Master's students in Software Engineering. We consider such an environment as a holistic pedagogical ecosystem that integrates digital educational resources, learning management systems, cloud services, collaborative software development tools, virtual laboratories, artificial intelligence technologies, and digital communication tools into a unified educational space. Its potential is realized through creating conditions for personalized learning, the development of research, project-based, and entrepreneurial activities, the formation of professional, digital, and innovative competencies, digital culture, innovative thinking, professional mobility, and the readiness of future Master's students in Software Engineering to design, develop, implement, evaluate, and commercialize innovative digital products in accordance with the contemporary challenges of digital transformation.

It is advisable to distinguish the following components of the digital educational environment of a higher education institution: technological (digital infrastructure, LMS, cloud services, code repositories, DevOps platforms); educational (digital content, adaptive learning, personalized learning pathways); innovative (the use of artificial intelligence technologies, project-based learning, startup culture); communicative (digital interaction among higher education students, academic staff, and IT companies); analytical (Learning Analytics, monitoring of learning achievements, digital portfolios); and security (cybersecurity, academic integrity, and digital ethics).

We believe that the potential of the digital educational environment is realized through a set of interrelated functions: educational, innovative, integrative, adaptive, and prognostic, the synergy of which ensures the preparation of future Master's students in Software Engineering for innovative activity (Fig. 1).

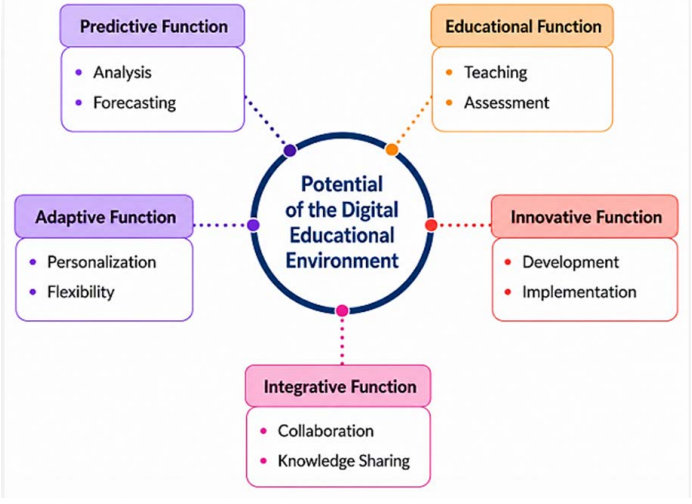


Fig. 1. The potential of the university digital educational environment in preparing future Master's students in Software Engineering for innovative activity

Let us consider these functions in greater detail.

The educational function consists in creating conditions for the development of the professional competencies of future Master's students in Software Engineering through the integration of digital educational resources, learning management systems, virtual laboratories, and specialized software. The digital educational environment provides

access to electronic courses, interactive learning materials, automated assessment, feedback tools, and collaborative software project development, making it possible to organize a continuous educational process, combine theoretical training with practical experience, and develop independent learning skills. For example, at Yuriy Fedkovych Chernivtsi National University (https://surl.li/ilirmq), a digital infrastructure operates that includes the Moodle platform, an electronic repository, and other university electronic services, providing access to learning materials, laboratory and project assignments, testing, and communication between academic staff and higher education students.

One example of the practical implementation of the potential of the digital educational environment is the Student Portal of Yuriy Fedkovych Chernivtsi National University (https://surl.li/obxafr). This digital service provides higher education students with centralized access to an electronic grade book, an individual study plan, class and examination schedules, an interactive map of the university buildings, reference information, and technical support services. In addition, the developers plan to expand its functionality by introducing a loyalty module with bonuses for active students, online course selection, a feedback system, and personalized analytical dashboards. A mobile application of the portal is also under development. For future Master's students in Software Engineering, such a digital ecosystem not only creates comfortable conditions for learning but also demonstrates practical approaches to the design, integration, and operation of modern information systems, thereby fostering readiness to develop innovative digital products.

The innovative function is aimed at developing the ability of future Master's students to create new digital products, use modern software engineering technologies, and participate in the development of innovative projects. The implementation of this function involves the integration of artificial intelligence technologies, DevOps approaches, software development automation tools, cloud technologies, and project-based learning.

The integrative function ensures interaction between the university and employers, IT companies, professional communities, and digital platforms. Its implementation creates opportunities for students to participate in joint projects, complete internships, work on real-world cases, and use professional digital services and academic licenses for modern software. Such interaction contributes to aligning the content of professional training with the needs of the IT industry and developing competencies demanded by employers. In particular, the development plan of the Department of Computer Systems Software at Yuriy Fedkovych Chernivtsi National University provides for the expansion of the use of Microsoft Azure for Education, GitHub Education, the modern educational platforms Moodle and Google Classroom, as well as strengthening cooperation with software developers (Development Plan of the Department of Computer Systems Software for 2025–2029).

The adaptive function ensures the personalization of the educational process, the development of individual learning pathways, the differentiation of learning tasks, and flexible access to digital resources regardless of the learners' location. Through digital platforms, students can independently plan the pace of their learning, receive prompt feedback, develop their own electronic portfolios, and carry out self-assessment of learning outcomes.

The prognostic function is aimed at preparing specialists in accordance with the development trends of the digital economy and the labour market. Its essence lies in the timely updating of the content of educational and professional programmes and the integration of modern software engineering technologies, artificial intelligence, data analytics, cybersecurity, and cloud computing into the professional training of future Master's students in Software Engineering.

To provide a comprehensive representation of the potential of the digital educational environment of a higher education institution, we consider it appropriate to present it in the form of a matrix (Table 1), which reflects the relationship between its main functions, the means of their implementation, and the expected outcomes of the professional training of future Master's students in Software Engineering for innovative activity.

Table 1

Matrix for Implementing the Potential of the Digital Educational Environment of a Higher Education Institution in Preparing Future Master's Students in Software Engineering for Innovative Activity

Function of the Digital Educational Environment	Implementation Tools and Means	Expected Outcome
Educational	Moodle LMS, digital courses, virtual laboratories	Intensification of the educational process, enhancement of independent learning, development of the professional competencies of future Master's students in Software Engineering
Innovative	GitHub, GitLab, GitHub Copilot, ChatGPT, hackathons, startup projects	Development of creativity, project-based thinking, and readiness for innovative activity
Integrative	Partnerships with IT companies, dual education, international projects	Integration of education, research, and practice; practical readiness for professional and innovative activity
Adaptive	Learning Analytics, adaptive platforms, personalized learning pathways	Individualization of learning and professional development in accordance with labour market needs
Prognostic	Analysis of IT market trends, foresight studies, digital analytics	Orientation toward future competencies and competitiveness

The proposed matrix confirms that the effectiveness of the digital educational environment is determined not by individual digital tools or technologies but by their comprehensive integration into the educational process, which ensures the preparation of future Master's students for solving complex professional tasks, carrying out innovative activities, and successfully adapting to the dynamic changes of the digital economy.

CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

The conducted study has confirmed that the potential of the digital educational environment of a higher education institution is an important factor in preparing future Master's students in Software Engineering for innovative activity. Its effective utilization ensures the integration of the educational, research, and practical components of professional training, creates conditions for the development of professional, digital, and innovative competencies, fosters digital culture, critical and creative thinking, and develops the ability for teamwork, project-based activity, and the development of digital software products.

We believe that the digital educational environment of a higher education institution is an important pedagogical resource that ensures personalized learning, enhances the independent and research activities of higher education students, promotes their professional mobility, readiness for lifelong learning, and effective activity in the context of the digital transformation of society.

We see prospects for further research in determining the criteria, indicators, and levels of the readiness of future Master's students in Software Engineering for innovative activity in the context of the digital educational environment of a higher education institution.

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