NON-FORMAL EDUCATION AS A FACTOR IN THE DEVELOPMENT OF STEM EDUCATION IN HIGHER EDUCATION IN UKRAINE AND THE UNITED STATES

UDC 37.0(477)+37.0(73)+374(477+73)+378(477+73)+37.013.74
DOI: 10.12958/2227-2747-2026-1(191)-39-54

Batyuk Liliia Vasylivna,
Ph.D. in Biology, Associate Professor,
Associate Professor of the Department of Physics and Chemistry,
H. S. Skovoroda Kharkiv National Pedagogical University,
Kharkiv, Ukraine.
l.batyuk@hnpu.edu.ua
https://orcid.org/0000-0003-1863-0265

Citation: Batyuk L. V. Non-Formal Education as a Factor in the Development of STEM Education in Higher Education in Ukraine and the United States. *Освіта та педагогічна наука*. 2026. № 1(191). С. 39–54. DOI: https://doi.org/10.12958/2227-2747-2026-1(191)-39-54

References (standard APA): Batyuk, L. V. (2026). Non-Formal Education as a Factor in the Development of STEM Education in Higher Education in Ukraine and the United States. *Osvita ta pedahohichna nauka – Education and Pedagogical Sciences, 1*(191), 39–54. DOI: https://doi.org/10.12958/2227-2747-2026-1(191)-39-54 [in English].

Statement of the problem. Non-formal education is an important component of the education system in any country, as it provides the opportunity to study outside the formal school and university, promotes the development of lifelong competence and adaptation to a rapidly changing socio-economic environment. In the global context, non-formal education plays the role of a catalyst for innovative approaches to learning, the introduction of digital technologies, the development of STEM skills and interdisciplinary thinking in the pedagogical and scientific and technical spheres.

An analysis of the history of the development of non-formal education in the USA and Ukraine during the 20th – 21st centuries allows us to identify both common patterns and the peculiarities of national models. In the USA, non-formal education was formed gradually, starting with vocational and labor training at the beginning of the 20th century, was integrated into the adult education system and is actively supported by federal programs (Adult Education, Workforce Development, STEM Education). In Ukraine, the development of non-formal education was more fragmented, under strong political and ideological influence during the Soviet period, and the current stage of its formation is associated with the independence of the state, European integration processes and the digital transformation of education.

Of particular importance in both countries is the non-formal education of teachers, in particular teachers of mathematics, physics and related STEM disciplines. It is implemented through trainings, internships, online courses, laboratory and experimental programs that contribute to the formation of professional competence, digital skills and an interdisciplinary approach to learning. An analysis of the historical development of non-formal education allows not only to trace the evolution of educational models,

but also to identify key factors that influence the integration of STEM into pedagogical practice and the development of teachers' digital competence.

Thus, a sciences and pedagogical analysis of the development of non-formal education in the USA and Ukraine is a necessary prerequisite for the modern concept of STEM education, digitalization of learning, and the development of professional competence of teachers within lifelong education.

Analysis of current research. The scientific and pedagogical aspect of the development of non-formal education in US higher education has been studied in the works of scholars such as Richard Arum and Josipa Roksa and although this study is not a study of non-formal learning itself, the authors deeply analyze the limited academic effectiveness of American higher education and emphasize that a significant part of student learning takes place outside the formal curriculum (Arum & Roksa, 2010). This approach contributes to the understanding of informal learning in the broader educational landscape of the US. No less interesting is the recent study which developed a model and measurement of informal student learning for the university environment (Decius et al., 2022). The authors adapted the Octagon Model of Informal Learning, which originated from research on informal learning in the workplace, to assess students' learning activities outside formal courses including self-educational activities, exchange of experience with peers, reflection and intuitive study of the material. The model's validity was found for self-efficacy and academic achievement, highlighting the importance of informal learning for student development in higher education. Informal learning spaces in US higher education are explored in the article by Wu Xianfeng et al. The study examines how non-formal learning spaces (corridors, student areas, cafes, libraries, etc.) can facilitate student learning outside the classroom. The authors identify key characteristics of the space (comfort, openness, flexibility, functionality) that influence students' choice of such areas for learning and interaction (Wu et al., 2021). Recent research (2020–2025) continues to recognize non-formal learning as a key component of the student experience, which is associated with academic success, self-efficacy, engagement, and other learning outcomes (Chandler et al., 2025; Johnson & Majewska, 2022; Almeida & Morais, 2025). In particular, recent work recognizes the need for scientific tools to measure non-formal learning and emphasizes its connection with formal learning and hidden learning, as known as aspects that are not always obvious in traditional curricula, because a significant part of student learning is unmeasured non-formal curriculum activities that need to be systematically recognized and measured in an academic context. Informal learning, in support of student learning, can be an important component of a successful educational ecosystem. Traditional higher education does not cover all paths of student learning, and therefore research into non-formal learning should be a priority.

Wide attention, within the framework of the study of informal education, in the US educational environment has the National Survey of Student Engagement (NSSE), which is a standardized tool for assessing student involvement in the educational process including informal learning activities (learning with peers, independent projects, participation in extracurricular activities, etc.). NSSE covers millions of students from over a thousand universities in the US and is considered a basic source of data on student learning engagement. Such research creates an empirical basis for assessing the part of student learning that does not belong

to the formal course, but has an impact on success and involvement (Evidence-Based Improvement in Higher Education, 2026). Organizational approaches to non-formal learning (within departments, centers and projects) are studied in the Center for Informal Learning and Schools (CILS) (Center for Informal Learning and Schools, 2026). This NSF–funded center in the US is mostly engaged in research on informal learning in the natural sciences outside of school and university contexts. And although the focus of the research is mostly on museums, science centers, etc., the work of CILS establishes methodological and conceptual foundations for understanding non-formal learning as a real educational practice that affects the acquired knowledge and skills. The main contribution is the creation of institutional approaches and theoretical frameworks that can be adapted also to higher education (for example, non-formal science education in STEM disciplines).

Scientific and pedagogical reviews of the university education system that emphasize the limitations of formal approaches and stimulate attention to non-formal learning as a separate phenomenon and in the context of higher education, adult education, professional development of teachers and integration with formal education were studied in the works of N. Shalova, O. Korbut, I. Stavytska who consider informal education as an alternative or complementary form to formal education that contributes to the development of professional and social competencies and adaptation to the dynamic demands of the labor market (Shalova et al., 2023). The authors emphasize that non-formal education should not be considered as "less important", but on the contrary, as a set of learning experiences outside formal courses that can be systematized. In the works of L. B. Luk'yanova in the monograph "Adult Education in Ukraine: Current Status and Development Prospects" which considers non-formal education as a component of continuous adult education, which is a logical continuation of formal adult education and an integral element of the educational path throughout life (Lukianova, 2020). It is noted that the Ukrainian adult education system is currently fragmented, and non-formal education requires legalization, standardization and methodological support. I. Meleshko, N. Khymay, N. Nikitina analyze non-formal adult education as a response to the needs of the modern labor market, the growing demand for digital and professional skills. The authors highlight key forms of non-formal learning (seminars, trainings, community courses), noting that they are often more effective than formal courses in developing practical competence (Meleshko et al., 2024). O. V. Anishchenko considers non-formal education in the broad sense of adult education, emphasizing that the success of such forms depends on the social context, employer support, and recognition of learning outcomes in professional qualification systems (Anishchenko, 2022). V. V. Kovtunets, V. M. Zakharchenko, D. M. Parmenova analyze the conditions for recognizing the results of non-formal learning in higher education, focusing on the need to develop a national system for recognizing such results for integration into formal education and career trajectories (Kovtunets et al., 2024). O. A. Dubaseniuk and O. A. Samoilenko examines various educational practices in higher education, paying attention to the combination of formal and non-formal learning in the education system, which allows optimizing the educational process and increasing the professional competence of students (Dubaseniuk & Samoilenko, 2020). M. Ostroha, V. Shamonia, O. Shershen investigate educational platforms that provide access to open educational resources: MIT OpenCourseWare,

EdX, Coursera, Udemy, EdEra, Prometheus, and justify that digital educational resources can be a tool for implementing non-formal education in a modern digital society (Ostroha et al., 2022). Ukrainian scientists and teachers lay the philosophical and conceptual foundations of understanding non-formal education, form the basis for further empirical research; analyze non-formal education in teacher training, emphasizing that extracurricular trainings, scientific seminars, workshops and professional communities contribute to the development of professional skills that are difficult to find in formal courses. These works emphasize the value of non-formal approaches for the professional development of teachers and lecturers, particularly in STEM disciplines, where constant updating of knowledge is critically important (Ponomarenko, 2019; Rybalko et al., 2023; Dotsenko & Ovod, 2025).

The purpose of the article. The purpose of the article is to conduct a scientific, pedagogical and comparative analysis of the development of non-formal education in the USA and Ukraine during the 20th – 21st centuries, determine its role in the formation and spread of STEM education in higher education, as well as identify leading trends, models and mechanisms for integrating non-formal educational practices into the system of teacher training.

Methodology and research methods. The methodological basis of the study is a systemic, historical-pedagogical, comparative and interdisciplinary approaches that provide a comprehensive study of the development of non-formal education in higher education in Ukraine and the USA during the 20–21st centuries in the context of the formation of STEM education.

The systemic approach made it possible to consider non-formal education as a holistic educational phenomenon that functions in conjunction with formal education, state educational policy, socio-economic factors and technological development. The historical-pedagogical approach was used to identify the stages of the evolution of non-formal education, the transformation of its goals, forms and content in accordance with social needs and scientific and technological progress.

The comparative approach provided a comparison of the Ukrainian and American experience in the development of non-formal education, in particular regarding regulatory and legal support, institutional models and practices of integrating STEM components into the training of pedagogical specialists. The interdisciplinary approach allowed us to involve the provisions of pedagogy, philosophy of education, sociology, educational policy and STEM studies for a deeper analysis of the problem under study.

The following methods were used in the research process: analysis, synthesis, generalization and systematization – to process scientific sources of Ukrainian and foreign authors; historical-logical analysis – to establish the patterns of development of non-formal education; comparative-pedagogical analysis – to identify common and distinctive features of non-formal education in the USA and Ukraine; content analysis of regulatory legal acts, educational strategies, programs and STEM initiatives; chronological method – to structure the material according to historical periods. The application of a set of these approaches and methods ensured the scientific validity, objectivity, and integrity of the research results, as well as the possibility of formulating generalized conclusions regarding the role of non-formal education in the development of STEM-oriented higher pedagogical education.

Presentation of the main material. The development of non-formal education as a factor in the development of STEM education in higher education in Ukraine and

the USA in the 20th – 21st centuries can be divided into several stages (see Table 1):

1. Initial stage (1900–1917).
2. The period of revolutions and the early Soviet stage (1917–1930s).
3. The Great Depression and World War II (1930–1945).
4. Post-war industrialization (1945–1960s).
5. Late Soviet period (1970–1980s).
6. Independence and transformation period (1991–2004).
7. European integration and digital stage (2005–2013).
8. Institutionalization and the modern stage (2014–2025).

At the beginning of the 20th century (1900–1917), non-formal education on Ukrainian lands was formed in the absence of its own statehood and being part of the Russian and Austro-Hungarian empires. The main forms of non-formal education were educational societies, folk universities, reading rooms, self-education circles, whose activities were of a national-cultural and civic nature. A special role was played by the organizations "Prosvita", pedagogical circles, Sunday schools for adults, where knowledge of mathematics, natural sciences, and technical basics of crafts was disseminated. Non-formal education of this period

Table 1

The development of non-formal education in the USA and Ukraine in the STEM-education context (the 20th – 21st)

Period	USA: key features of development	USA: STEM component/ pedagogical integration	Ukraine: key features of development	Ukraine: STEM component/ pedagogical integration
1900–1917	Educational and professional circles, workers' schools	Initial knowledge of mathematics, natural sciences, technical skills; teacher training	Society "Prosvita", folk universities, Sunday schools	Elementary mathematics and natural sciences; popularization of science (the beginnings of STEM)
1917–1930	Courses for adults, elimination of illiteracy; workers' circles	Teacher training, integration of applied STEM knowledge	Rabfakas (work faculties), schools for working youth, technical circles	Technical education, applied mathematics and physics; formation of engineering thinking
1930–1945	Community service programs (CCC, WPA); training of unemployed adults; vocational retraining; military-technical training of the population	Non-formal education performed an adaptive and compensatory function, complementing the formal system	Advanced training courses; technical houses; mass training for industry	Engineering and technical training; physics, mechanics, electrical engineering; prototypes of STEM laboratories
1945–1960	Technology buildings, science clubs, STEM laboratories	Physics, engineering, digital tools; internships for teachers	Stations of young technicians, pioneer houses, science and technology clubs	Engineering and technical projects; interdisciplinary STEM tasks
1970–1980	Olympiads, electives, STEM workshops for teachers	In-depth study of physics and mathematics; development of logical and algorithmic thinking	Extracurricular clubs, Olympiads, methodological seminars	Experimental projects; integration of physics and mathematics; development of interdisciplinary skills

Continuation of table 1

Period	USA: key features of development	USA: STEM component/ pedagogical integration	Ukraine: key features of development	Ukraine: STEM component/ pedagogical integration
1991–2004	Online courses, international programs, professional STEM trainings	Mathematics, physics, computer science, beginning of digital literacy	Public organizations, international projects, teacher training courses	Beginning of STEM integration: digital technologies, applied mathematics and physics
2005–2013	Bologna process, MOOCs, STEM laboratories, research internships	Digital STEM tools, laboratory simulations, computational methods	International programs (Tempus, Erasmus), online platforms	STEM projects, digital laboratories, interdisciplinary tasks for teachers
2014–2019	STEM integration in teacher training, maker spaces, coding bootcamps	Digital badges, micro-credentials, computational thinking	Activation of online courses, trainings for teachers	STEM laboratories, interdisciplinary projects, digital tools for physics and mathematics
2020–2025	Mass digitalization and distance learning, AI tools, STEM environments	Full integration of STEM, programming, data science, modeling	Digital platforms, online STEM courses, normative recognition of non-formal education	Full STEM integration: digital laboratories, modeling, STEAM projects for teachers

served as a compensation for limited access to formal education and contributed to the formation of elementary scientific ideas. In the United States, in the early 20th century, informal education was formed mainly through vocational schools, worker's clubs, and community educational organizations. The main goal was to spread basic knowledge in the labor, technical, and scientific fields, which became the foundation for future STEM programs. At the same time, in the pedagogical context, the first courses for training teachers of mathematics and natural sciences appeared within the framework of public and professional societies.

The period of the Revolution and the early Soviet stage (1917–1930s) was characterized by attempts to create a national education system, within which non-formal education was considered a means of eliminating illiteracy and spreading scientific and technical knowledge among the population. In the 1920s and 1930s, non-formal education in Soviet Ukraine became widespread through: workers' faculties (rabfaks), schools for workers' and peasant youth, technical minimum courses, scientific and technical circles. At the same time, it was ideologized and tightly controlled by the state, which limited autonomy and voluntariness as key features of non-formal education. In the United States, the development of non-formal education during this period was focused on adult vocational training, the elimination of illiteracy, and the involvement of citizens in scientific and technical activities. Teachers were given access to seminars and short-term courses for advanced training.

The period of the Great Depression and World War II (1930–1945) was characterized by profound socio-economic transformations that directly affected the education systems in both countries. In the context of resource shortages, population mobilization, and the reorientation of the economy

to industrial and military-technical needs, non-formal education became an important mechanism for rapid training, primarily in areas that are today defined as STEM (science, technology, engineering, mathematics). In the USA in 1930–1945, non-formal education played a compensatory and innovative role, complementing the formal education system with the following key characteristics: active development of public technical training programs (workshops, evening classes, extension programs); the spread of on-the-job training in industry, engineering, mechanics, and electrical engineering; the involvement of universities in extracurricular training of engineers, technicians, and physicists for the defense industry; support for popular science education through science museums, radio programs, and public lectures that contributed to the formation of engineering and scientific thinking (Batyuk, 2025). As a factor in the development of STEM education in higher education, non-formal education in the United States contributed to: the development of applied physics and engineering knowledge; the formation of technical competencies necessary for aviation, radar technologies, and weapons production; the formation of a culture of scientific and technical literacy among the population, which became the basis of the post-war STEM breakthrough (Batyuk & Zhernovnykova, 2025).

In Ukraine (as part of the USSR), non-formal education as an element of ideologized industrialization in 1930–1945 developed within the framework of the Soviet educational and ideological model, strictly subordinated to state goals. Key characteristics: the functioning of workers' faculties (labfaks), technical circles, advanced training courses; mass involvement of young people in industrial training at enterprises, especially in the fields of mechanical engineering, energy, and metallurgy; development of military-technical training through voluntary societies (DTSAAF and its predecessors); use of non-formal education as a tool for the rapid elimination of technical illiteracy. As a factor in the development of STEM education in higher education, non-formal education in Ukraine contributed to: the dissemination of elementary knowledge in physics, mechanics, mathematics; the formation of technical skills for the needs of the military economy; practical orientation of learning without the development of critical thinking and scientific autonomy.

After World War II (1940–1960s), non-formal education in Ukraine was closely linked to the processes of industrialization and reconstruction. The main emphasis was on improving the skills of workers, technical training, dissemination of engineering and natural science knowledge. Houses of technology, stations of young technicians, scientific and technical societies were formed, which can be considered the predecessors of modern STEM centers. In the pedagogical environment, advanced training courses, seminars, methodological associations developed as forms of non-formal education of teachers. In the United States, the role of technology houses, science clubs, and STEM laboratories for students and teachers has increased. The emphasis has been on training specialists for engineering and science. The emergence of NASA and NSF programs has opened up opportunities for physics and mathematics teachers to master modern scientific methods and digital tools (Batyuk, 2025).

In the late Soviet period (1970–1980s), non-formal education functioned mainly within the framework of the system of out-of-school education, advanced training courses, mass popular science programs. A characteristic feature of the period was the combination of formal and out-school

education, although the latter was not recognized as an autonomous sphere. Technical Olympiads, clubs in mathematics, physics, and electronics became widespread, laying the foundation for the future STEM movement. In the United States at this time, state support for career and technical education, including advanced training and adult education programs, was institutionalized (Neff, 1974; Knowles, 1980; Perkins, 1984).

After Ukraine gained independence (1991–2004), non-formal education began to develop in the context of democratization and decentralization. Public educational organizations, international educational projects, and retraining courses for teachers and specialists appeared. However, there was no legislative recognition of non-formal education, which hindered its institutional development. During this period, non-formal education played the role of an adaptation mechanism to socio-economic changes. In the United States, digitalization and interdisciplinary learning are on the rise in non-formal education. The emergence of online courses and professional STEM training for teachers has allowed for the integration of classical mathematics and physics with computer science and engineering (Batyuk, 2024).

After Ukraine joined the Bologna Process (2005–2013), the development of adult education and non-formal learning intensified. The role of trainings, short-term courses, and international programs Tempus, Erasmus increased. Non-formal forms of professional development of teachers began to spread in the pedagogical sphere, in particular in mathematics, physics, and computer science. Prerequisites were laid for the implementation of STEM approaches (Drop in education, 2018). In the US, non-formal education is becoming an integrated system of professional development, including STEM programs, laboratory simulations, digital training, and research internships for teachers.

The period after 2014 became a turning point for the development of non-formal education in Ukraine. There was an increase in the role of civil society, the active implementation of online education, the emergence of educational platforms Prometheus, EdEra. Non-formal education increasingly focused on a competency-based approach, digital technologies and interdisciplinarity, which became the basis for the development of STEM education (Law of Ukraine "On Higher Education", 2014; Law of Ukraine "On Education", 2017). In the US, STEM non-formal education is becoming a strategic part of teacher training, with clear regulatory and financial support (American Innovation and Competitiveness Act, 2017). Digital badges, microcredentials, maker spaces, coding bootcamps, computational physics are being introduced (Batyuk, 2024).

The history of the development of non-formal education during the years of Ukraine's independence, 1991–2025, testifies to its evolution from spontaneous educational initiatives to a strategically important component of the national education system. At the current stage, non-formal education plays a key role in the training and professional development of teachers, particularly in the context of digital transformation and STEM education (Yurchenko & Semenikhina, 2023; Batyuk, 2025; Resolution of the Cabinet of Ministers of Ukraine, 2021; Order of the Ministry of Education and Science of Ukraine, 2022).

The current stage, which can be distinguished from 2019 to 2025, has brought to the educational environment such challenges as digitalization, STEM and education in times of crisis. In 2019–2025, the development of non-formal education in Ukraine took place in the context of the COVID-19 pandemic and a full-scale war. This has led to the rapid digitalization of educational processes, the mass distribution of online courses

and the growing role of non-formal education for teachers, the development of individual educational trajectories and the improvement of the educational process, the recognition of learning outcomes of non-formal and informal education in the formal education system, confirmation of professional qualifications, the recognition at the levels of complete general secondary education of learning outcomes obtained through formal and/or informal education in educational entities located abroad, the recognition in higher and professional pre-higher education of learning outcomes obtained through non-formal and/or informal education, etc. (Resolution of the Cabinet of Ministers of Ukraine, 2025; Order of the Cabinet of Ministers of Ukraine, 2025; Order of the Ministry of Education and Science of Ukraine, 2025). Non-formal education has become a key tool for professional support for teachers, the implementation of STEM approaches, and the development of digital, mathematical and natural competences.

Conclusions and prospects for further research. The study showed that informal education is a significant factor in the development of STEM education in higher education in Ukraine and the USA, performing the function of a flexible supplement to the formal training of future specialists and pedagogical personnel. During the 20th – 21st centuries, informal education transformed from episodic educational initiatives into a systemic component of continuous professional development, especially in STEM fields that require rapid updating of knowledge and skills.

It was established that in the USA, informal education in the university environment developed on the basis of academic autonomy, partnership with research institutions and industry, which contributed to the active integration of project-based learning, research programs, massive open online courses and professional communities in STEM education. This provided stable mechanisms for updating the content of training and increasing the competitiveness of graduates.

In Ukraine, non-formal education in higher education has historically been shaped by state educational policy and socio-economic challenges, and at the current stage it is acquiring the characteristics of an open educational ecosystem, which includes STEM centers, educational platforms, public initiatives and international projects. It has been proven that informal STEM practices contribute to the development of practical competencies, interdisciplinary thinking and professional mobility of higher education students.

A comparative analysis showed that common features for both countries are an orientation towards the practical orientation of learning, interdisciplinarity and partnership interaction, while the differences are due to the level of institutional support, funding and regulatory recognition of the results of informal education. At the same time, the American experience confirms the feasibility of systematically integrating informal STEM education into the development strategy of universities, which is a promising direction for the modernization of Ukrainian higher education.

Prospective areas of further scientific exploration are in-depth study of the mechanisms of institutional recognition of the results of informal STEM education in higher education; analysis of the effectiveness of digital and online forms of informal STEM education in the training of future teachers and lecturers; development of models for the integration of formal and informal education in STEM teacher training; research into the impact of informal education on the formation of STEM competencies, innovative thinking and professional identity of students; comparative analysis of the experience

of other countries in order to adapt the best international practices to the conditions of the Ukrainian higher education system. Implementation of the above areas will contribute to improving the quality of STEM education, developing a culture of lifelong learning and integrating Ukrainian higher education into the global educational space.

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Батюк Л. В. Неформальна освіта як чинник розвитку STEM-освіти у вищій школі України та США

У статті здійснено науково-педагогічний і компаративний аналіз розвитку неформальної освіти у США та в Україні впродовж XX–XXI століть задля визначення її ролі у становленні та розвитку STEM-освіти у вищій школі. Актуальність дослідження зумовлена зростанням значущості неформальних освітніх практик у формуванні STEM-компетентностей здобувачів вищої освіти в умовах цифровізації, швидкого оновлення науково-технологічних знань і переходу до моделі навчання впродовж життя.

Методологічну основу дослідження становлять системний, історико-педагогічний і компаративний підходи. У роботі використано методи аналізу та узагальнення наукових джерел, контент-аналіз нормативно-правових документів, порівняльно-педагогічний і хронологічний аналіз.

У результаті дослідження встановлено, що у США неформальна освіта формувалася як цілісна та інституційно підтримана система, яка з початку XX століття охоплювала професійні школи, освітні товариства й громадські ініціативи з елементами природничо-математичної підготовки. У другій половині XX століття за підтримки федеральних організацій відбулася активна інтеграція STEM-компонента, а у XXI столітті – розвиток цифрових курсів, онлайн-платформ і програм підвищення кваліфікації педагогів.

В Україні розвиток неформальної освіти мав етапний характер: від просвітницьких форм початку XX століття та технічних гуртків радянського періоду до сучасних STEM-центрів, онлайн-платформ і міждисциплінарних програм для педагогів. Сформульовано висновок, що США мають стабільну систему підтримки неформальної STEM-освіти, тоді як в Україні цей процес є поступовим, але стратегічно значущим для модернізації вищої освіти.

Ключові слова: неформальна освіта, STEM-освіта, вища освіта, STEM-компетентності, неперервне навчання, порівняльна педагогіка, Україна, США.

Batyuk L. V. Non-Formal Education as a Factor in the Development of STEM Education in Higher Education in Ukraine and the USA

The article provides a scientific, pedagogical and comparative analysis of the development of non-formal education in the USA and Ukraine during the 20th–21st centuries in order to determine its role in the formation and development of STEM education in higher education. The relevance of the study is due to the increasing importance of non-formal educational practices in the formation of STEM competencies of higher education students in the context of digitalization, rapid updating of scientific and technological knowledge and the transition to a lifelong learning model.

The methodological basis of the study is a systematic, historical, pedagogical and comparative approach. The work uses methods of analysis and generalization of scientific sources, content analysis of regulatory documents, comparative pedagogical and chronological analysis.

The study found that in the USA, non-formal education was formed as a holistic and institutionally supported system, which since the beginning of the 20th century has included vocational schools, educational societies and public initiatives with elements of natural and mathematical training. In the second half of the 20th century, with the support of federal organizations, the STEM component was actively integrated, and in the 21st century, digital courses, online platforms and teacher training programs were developed.

In Ukraine, the development of non-formal education was staged from educational forms of the early 20th century and technical circles of the Soviet period to modern STEM centers, online platforms and interdisciplinary programs for teachers. It was concluded that the USA has a stable system of support for non-formal STEM education, while in Ukraine this process is gradual, but strategically significant for the modernization of higher education.

Key words: non-formal education, STEM education, higher education, STEM competencies, lifelong learning, comparative pedagogy, Ukraine, USA.

Date of initial submission: 07.02.2026
Date of acceptance for publication following peer review: 05.03.2026
Date of publication: 22.04.2026