РОЗДІЛ V. ПРОБЛЕМИ ПОРІВНЯЛЬНОЇ ПЕДАГОГІКИ

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GENESIS AND CURRENT STATE OF STEM EDUCATION DEVELOPMENT: U.S. EXPERIENCE

The article reveals genesis and current state of STEM education development in the USA. The factors (political, economic, cultural, educational) that influenced STEM education development are revealed. The legal regulations on STEM education in the USA at different stages of its development are characterized. The innovative trends in STEM education development are highlighted, namely: extending STEM definition; enhancing STEM teachers training and professional development; improving STEM courses; broadening participation of girls, women and minorities in STEM; increasing federal financial support of STEM education; establishing cooperation in the process of STEM services provision between a wide range of institutions, including federal agencies, public and private organizations, academic institutions, foundations, business companies, etc.

Key words: *STEM education, genesis of STEM education, legal regulations of STEM education development, USA.*

Introduction. In modern conditions of society development, preparing highly qualified STEM specialists becomes a priority educational agenda in many countries. STEM skills are vital to become a competitive specialist at the labor market. Realizing the necessity to develop STEM field, Ukraine implemented "The concept of Science and Mathematics Education (STEM Education) development", aimed at promoting Science and Mathematics Education (STEM Education) as a basis for competitiveness and economic growth of the state, formation of the innovative competences of its citizens, training of new generation, capable of learning as well as developing and using new technologies. At the same time, there are still unresolved issues on the way to implement the Concept. One of the possibilities to solve the outlined problems is to learn positive experience of the countries, which have achieved success in developing STEM education at different levels of the education system. One of such countries is Ukraine.

Analysis of relevant research. Due to its relevance, the issue of STEM education development has been considered by many scientists in Ukraine and abroad. Among Ukrainian scientists we can name V. Andriievska, S. Babiichuk, O. Barna, M. Boichenko, I. Chernetskyi, V. Chernomorets, S. Dembitska,

S. Halata, O. Hirnyi, O. Kiian, O. Korshunova, O. Kurnosenko, O. Kuzmenko, S. Kyrylenko, R. Levytska, O. Lozova, N. Morze, O. Patrykeieva, N. Polikhun, S. Podliesnyi, I. Savchenko, A. Sbruieva, S. Sioma, I. Slipukhina, H. Skrypka, O. Stryzhak, O. Tarasov, V. Zaiarna and others.

At the same time, the researchers haven't focused specifically on the history and factors that influenced STEM education development in the USA. Taking into account this fact, the **aim** of our article was defined – to reveal genesis of STEM education development in the USA and its current trends.

To achieve the goal, the following **research methods** were used: theoretical – analysis, synthesis, generalization, comparison – to reveal the essence of the studied phenomenon; historical-genetic method – to determine the factors that influenced STEM education development and to study the process of STEM education development in the historical retrospective; structural-logical method – to highlight the current trends in the development of the studied phenomenon at the modern stage of society development.

Research results. Considering the origins of STEM education in the United States, the researchers are unanimous in their opinion that the impetus for the development of STEM education was launching of the Russian satellite in 1957. In response, in 1958, President of the USA D. Eisenhower established the National Aeronautics and Space Administration (NASA). In 1961, President J. F. Kennedy continued the course of President D. Eisenhower, promoting scientific innovation and sending astronauts to the moon.

During 70's – 80's of the 20th century, the most notable technological advances that continued to affect the American nation were cell phones and personal computers. An artificial heart was created for the first time, and the first space shuttle was launched. In the United States, a number of national research programs were introduced. In 1996, the National Research Council developed the National Science Education Standards (NSES).

Earlier, in 1989, the National Council of Teachers of Mathematics (NCTM) introduced the Curriculum and Evaluation Standards for School Mathematics, and in 1991 the Professional Standards for Teaching Mathematics and Assessment Standards for School Mathematics. These standards and guidelines allowed to form a curriculum for students of secondary schools (K-12) in STEM disciplines. For the first time was used the acronym SMET, which later was substituted by the acronym STEM.

In early 2000s actualized the issue of increasing STEM educational opportunities and student learning. In particular, in 2001, the then governor of Arizona J. Napolitano created a STEM development program, which received

federal and private funding, and other states followed this example by setting up STEM councils in their states to support the education initiative.

The No Child Left Behind Act (NCLB) (2001) had become a response to the alleged "non-competitiveness" of the United States in academic events. The law made schools responsible for ensuring the success of their students at a high academic level. Nevertheless, the report of the US National Academy of Sciences, Engineering and Medicine (2005) emphasized that the level of knowledge of US citizens in the field of STEM lagged behind other countries. Consequently, there arose the necessity to consolidate efforts in increasing K-12 students' outcomes in STEM.

In accordance with the provisions of the America COMPETES Act (2007), federal funding was allocated for STEM education development. The law provided for the creation of a new federal initiative to train 70,000 new STEM teachers in Advanced Placement and International Baccalaureate courses, as well as initiatives aimed at involving existing STEM teachers in professional development programs and encouraging university students, who studied in the STEM field, to receive teacher certificates. However, despite efforts, there was still a significant shortage of STEM qualified teachers throughout the country (Lips & McNeill, 2009).

It should be stressed, that great attention to STEM education development in the USA paid President B. Obama, who launched numerous initiates. One of these initiatives was "Educate to Innovate" (2009). It was aimed at providing American students with the best opportunities for future STEM employment. Federal investment in STEM education was increased, and the country had set a benchmark to train 100,000 highly qualified STEM teachers during the next ten years.

In 2010, in accordance with the requirements of Section 101 of the outlined above America COMPETES Act, the Committee on STEM Education (CoSTEM) was establishment. The CoSTEM was empowered to fulfill the following functions:

- review educational programs in the field of Science, Technology, Engineering and Mathematics (STEM), invest in their implementation and evaluate their effectiveness;
- coordinate educational programs, investments and activities of federal agencies with the Office of Management and Budget;
- develop and implement through the involved agencies a strategic plan in the field of STEM education, which should be updated every five years (*President Obama Launches "Educate to Innovate"…,* 2010).

In its turn, the Federal Coordination in STEM Education (FC-STEM) Subcommittee advises and assists the Committee on STEM Education and serves as a forum to facilitate the formulation and implementation of the strategic plan.

In the same year, President B. Obama announced creation of the non-governmental organization "Change the Equation", aimed at improving the quality of STEM education in the country.

In order to fulfill the task, outlined in the "Educate for Innovate" initiative (training 100,000 effective STEM teachers over the next 10 years), the national innovative educational network 100Kin10 was established in 2011 with the support of 28 founding partners, bringing together leading academic institutions, non-profit organizations and foundations, companies and federal agencies.

During the first four years of the organization's existence, its partners trained more than 30,000 new effective STEM teachers and conducted professional development courses for thousands of practicing teachers (100Kin10, 2011).

In order to identify students' understanding of technology, design and systemic technological thinking and the impact of technology on society, the Technology and Engineering Literacy Assessment was conducted in 2014 among the selected participants.

A very important benchmark in US STEM education development became adoption in 2015 of the Law on STEM Education, which added Computer Science to the definition of STEM areas and introduced more advanced curriculum for teachers.

In particular, Section 2 of the Act states that "for the purpose of providing STEM education services the National Science Foundation, the US Department of Energy, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Institute of Standards and Technology and U.S. Environmental Protection Agency the term "STEM education" should apply to such subjects as Science, Technology, Engineering, and Mathematics, including Computer Science" (*HR1020 – STEM Education Act of 2015*).

The law envisages provision of grant support on a competitive basis by the director of the National Science Foundation through the Directorate for Education and Human Resources for conducting research, developing innovative out-of-school STEM education institutions and creation of STEM learning environment to improve results of training in the field of STEM, as well as enhance non-formal STEM education (ibid.).

The Law emphasizes that grant support covers both a single STEM discipline and a number of STEM disciplines or integrated STEM disciplines and

includes: 1) research and developments that promote a better understanding of the essence of learning and interaction in the non-formal environment, in particular, on the role of an informal environment in expanding participation in STEM; 2) design and testing of innovative STEM learning models, programs and other resources in order to create a non-formal learning environment to improve learning outcomes in the STEM field and increase involvement of students, secondary school (K-12) teachers and wide community.

One more important event in STEM education development in the USA was adoption of the "Every Student Succeeds Act" (ESSA) (2015), which regulated the national policy in the field of public general secondary education (K-12) in the country. The law amended, but did not repeal, the provisions of the "No Child Left Behind Act" regarding periodic standardized tests to be taken by students.

The main provisions of the Law include:

- ensuring equal access to education for all students, protecting interests of different categories of students;
- teaching all students in the United States in accordance with high academic standards, which should be the key to their successful college education and choice of profession;
- providing vital information to teachers, families, students and local communities through annual staff assessments, which measure students' progress in meeting these standards;
- support (including financial) and development of innovations in local communities, especially disadvantaged ones, within the Promise Neighborhoods program;
- increasing funding aimed at expanding access to quality preschool education;
- promoting positive change in the least effective schools, where groups of students do not progress and where the level of graduates is low over a long period of time.

It should be noted that the Law provides funding for various areas of STEM education. In particular, under Title I "Improving Basic Programs Operated by State and Local Educational Agencies", federal funding may be used by schools operating under the school curriculum: to upgrade existing STEM labs and laboratory materials or other specialized training spaces; improve STEM-courses; conduct field trips to expand access to real, practical experience in the field of STEM, including experience that expands students' knowledge of the impact of STEM in the world.

Funding under Title II “Preparing, Training, and Recruiting High-Quality Teachers, Principals, or Other School Leaders” may be used for the following purposes: train educators to teach new concepts and approaches in the field of STEM, including Computer Science; provide scholarships to attract teachers to STEM professions; recruit highly qualified specialists from other fields who can become STEM teachers; provide teachers with opportunities for professional development; support teachers in the process of implementing such new courses as Computer Science and Engineering; support teachers who provide effective STEM education services to students with disabilities; support for STEM primary school teachers, as well as educators of preschool education institutions, which include teaching of STEM-disciplines in the educational process; professional training or professional development for teachers aimed at incorporating technology into the effective teaching of STEM disciplines through personalized or blended learning; establish cooperation between schools, out-of-school education institutions, providers of non-formal educational services to facilitate integration of STEM disciplines; involve STEM-coaches, who should help the grantees to adapt teaching to the needs of individual teachers; provide differentiated salaries or stimulate STEM teachers working in schools with high needs, or reward teachers and school principals whose students have demonstrated high learning outcomes in STEM (*National Science Teachers Association,* 2017).

Under Title IV “A Student Support and Academic Enrichment Grants”, federal funding extends to the following areas: safe and drug-free schools; mental health counseling; consultancy; music education; civic education; testing within the framework of International Baccalaureate or Advanced Placement programs; STEM.

According to the law, districts can use federal funding to achieve the following goals: increase the number of quality STEM courses; expand access to STEM education for students at risk; support for student participation in non-profit STEM competitions; ensure the acquisition of practical experience in teaching STEM-disciplines; integrate other subjects, including art, into STEM subject programs; create or improve special STEM-schools; integrate school, out-of-school and non-formal STEM education; expand environmental education (*National Science Teachers Association,* 2017).

The course on further STEM education development was supported by the next U.S. President D. Trump. In December 2018, the Strategic Plan “Charting a Course for Success: America’s Strategy for STEM Education” was published. The document represents a federal strategy for the next five years based on a vision of

the future, where all Americans will have access to high-quality STEM education throughout their lives, and the United States will be a world leader in STEM literacy, innovation and employment. The strategic plan calls for nationwide collaboration with students, their families, educators, local communities and employers, the "polar star" for the STEM community, as they work together to set the course for the nation's success. The US Department of Education is an active participant in each of the interagency working groups focused on the implementation of the defined plan (*Charting a Course for Success…,* 2018).

The strategic plan of STEM education provides for the achievement of the following goals:

- creating a solid foundation for the STEM literacy development, providing every American with the opportunity to master the basic concepts of STEM, including computational thinking, and acquire digital literacy. Citizens with STEM literacy will be better prepared to respond to the challenges posed by the rapid technological change and participate in civil society;
- increasing diversity, equality, and STEM integration, and ensure that all Americans have access to high-quality lifelong STEM education, especially those who have not received STEM education before;
- training STEM professionals for the future – both STEM graduates and qualified college graduates – by creating a true learning experience that encourages and prepares graduates for further careers in STEM. Creating a diverse pool of talented Americans, who have deep knowledge in STEM disciplines and are ready to work in future will play an important role in the national innovation base that supports key sectors of the economy, as well as scientific discoveries and future technologies (*Progress Report…,* 2019).

The outlined strategy envisages that a number of successive steps in the following areas will contribute to the achievement of the defined goals:

- developing and enriching strategic partnerships to build new or strengthen existing links between education institutions and the wider communities they serve;
- involving students in areas where disciplines converge, and STEM is a means of combining them;
- formation of computational literacy with the help of STEM education, which provides deeply formed computational skills with the help of digital tools;
- ensuring transparency and accountability in the federal authorities implementing the plan, using evidence-based practices and evaluation tools that can be followed by other STEM stakeholders (*Charting a Course for Success…,* 2018)

Conclusions. Having revealed the genesis of STEM education development and its current state we came to the following conclusions. The phenomenon under study has originated and developed under the influence of a number of factors, namely: political (political actions of the USA on world arena, changes in domestic and foreign policy of the country, striving for world leadership, etc.), economic (need to increase competitiveness of future specialists at the labor market, increased funding, creation of professional networks, etc.), cultural (forming values of digital society, digital citizenship, which involves STEM literacy, etc.), and educational (changes in the structure and essence of STEM education, introduction of new ideas, concepts, samples of the best educational experience, etc.).

Analysis of the important legal regulations on STEM education (Educate to Innovate, America COMPETES Act, STEM Education Act, Every Student Succeeds Act, Charting a Course for Success: America's Strategy for STEM Education and so on) allowed to characterize the current trend in STEM education development, namely: extending STEM definition; enhancing STEM teachers training and professional development; improving STEM courses; broadening participation of girls, women and minorities in STEM; increasing federal financial support of STEM education; establishing cooperation in the process of STEM services provision between a wide range of institutions, including federal agencies, public and private organizations, academic institutions, foundations, business companies, etc.

Present study does not cover all the aspects of the specified phenomenon, **the prospects of further research** are seen in considering the content-procedural foundations of STEM education in U.S. high schools.

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АНОТАЦІЯ

Бойченко Віталій. Ґенеза і сучасний стан STEM-освіти: досвід США.

Стаття розкриває ґенезу та сучасний стан STEM-освіти в США. Виявлено низку чинників, що справили вплив на розвиток STEM-освіти досліджуваної країни, а саме: політичні (політичні дії США на світовій арені, зміни у внутрішній та зовнішній політиці країни, прагнення до світового лідерства тощо), економічні (необхідність підвищення конкурентоспроможності майбутніх фахівців на ринку праці, збільшення фінансування, створення професійних мереж тощо), культурні (формування цінностей цифрового суспільства, цифрове громадянство, що передбачає розвиток STEM-грамотності тощо), та освітні (зміни в структурі та сутності STEM-освіти, упровадження нових ідей, концепцій, зразків найкращих освітніх практик тощо). Окреслено нормативні документи щодо STEM-освіти в США на різних етапах її розвитку (Закон «Виховуй для інновацій», Закон «Про конкуренцію Америки», Закон «Про STEM-освіту», Закон «Кожен учень досягає успіху», Стратегічний план «Курс на успіх: американська стратегія STEM-освіти» тощо). Висвітлено інноваційні тенденції розвитку STEM-освіти, а саме: розширення визначення поняття STEM; удосконалення професійної підготовки та підвищення кваліфікації вчителів і викладачів STEM; удосконалення курсів зі STEM-дисциплін; розширення участі дівчат, жінок та меншин у галузі STEM; збільшення федеральної фінансової підтримки STEM-освіти; налагодження співпраці в процесі надання послуг у галузі STEM-освіти між широким колом установ, включаючи федеральні агенції, державні та приватні організації, заклади освіти різних рівнів, фонди, бізнес-компанії тощо.

Ключові слова: *STEM-освіта, ґенеза STEM-освіти, нормативні документи, що регулюють розвиток STEM-освіти, США.*

РЕЗЮМЕ

Бойченко Виталий. Генезис и современное состояние STEM образования: опыт США.

В статье раскрыты генезис и современное состояние STEM-образования в США. Выявлены факторы (политические, экономические, культурные, образовательные), повлиявшие на развитие STEM-образования. Охарактеризованы нормативные документы по STEM-образованию в США на разных этапах его развития. Выделены инновационные тенденции в развитии STEM-образования, а именно: расширение определения понятия STEM; повышение уровня профессиональной подготовки и квалификации учителей и преподавателей STEM; совершенствование курсов STEM; расширение участия девочек, женщин и меньшинств в STEM; увеличение федеральной финансовой поддержки STEM-образования; установление сотрудничества в процессе предоставления услуг в сфере STEM-образования между широким кругом учреждений, включая федеральные агентства, государственные и частные организации, академические учреждения, фонды, коммерческие компании и т. д.

Ключевые слова: *STEM-образование, генезис STEM-образования, нормативные документы, которые регулируют развитие STEM-образования, США.*