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THE EVOLUTION OF STEM EDUCATION IN THE UNITED STATES: AN ANALYSIS OF THE INSTITUTIONAL DISTRIBUTION OF EDUCATIONAL PROGRAMS AND UNIVERSITY RANKINGS

The article provides a comprehensive analysis of the development of STEM education in the United States of America in a historical perspective (1940–2026) using pedagogical, institutional, and quantitative approaches. The study is aimed at identifying patterns in the formation and expansion of STEM educational programs at leading US universities, as well as determining their role in the formation of an innovative educational ecosystem.

The methodological basis of the study is a combination of historical-pedagogical, comparative, statistical, and bibliometric methods. Particular attention is paid to the use of the Classification of Instructional Programs system USA as a tool for standardized classification of educational programs, which allows for their quantitative and structural analysis. The results of ranking US universities by the number of implemented STEM programs as of 2026, taking into account specialty codes (CIP) presented. It was established that the leading positions are occupied by both elite research universities and large state higher education institutions, which provide mass training of specialists in the fields of science, technology, engineering and mathematics.

Reviewed the graph of the evolution of STEM programs in the USA, the main stages of their development were determined: from the initial formation in the middle of the 20th century to intensive growth in the 21st century, caused by digitalization, the development of artificial intelligence and interdisciplinary research. It is proved that the number of STEM programs is an important indicator of the development of the educational environment, reflects the level of innovation of universities and their ability to adapt to the needs of the labor market.

From a pedagogical and scientific point of view, it is substantiated that modern STEM education is transforming into an interdisciplinary system focused on the formation of 21st century competencies of educators and learners, critical thinking and innovative potential of education seekers. The combination of tabular and graphical analysis allowed us to form a holistic picture of the structural and dynamic characteristics of the development of STEM education in the USA.

The results of the study can be used to improve educational policy Ukraine, develop new curricula, as well as conduct comparative research and adapt best practices of STEM education in an international context.



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Keywords: *STEM education, STEM program, higher education, university, educational programs, Classification of Instructional Programs, United States of America, Ukraine.*

Батюк Л. В. Еволюція STEM-освіти у США: аналіз інституційного розподілу освітніх програм і ранжування університетів. У статті представлено комплексний аналіз розвитку STEM-освіти у Сполучених Штатах Америки в історичній перспективі (1940–2026) з використанням педагогічного, інституційного та кількісного підходів. Дослідження спрямоване на виявлення закономірностей у формуванні та розширенні освітніх програм STEM у провідних університетах США, а також визначення їхньої ролі у формуванні інноваційної освітньої екосистеми.

Методологічною основою дослідження є поєднання історико-педагогічних, порівняльних, статистичних та бібліометричних методів. Особлива увага приділяється використанню системи Класифікації навчальних програм США як інструменту стандартизованої класифікації освітніх програм, що дозволяє проводити їх кількісний та структурний аналіз. Представлено результати ранжування університетів США за кількістю впроваджених STEM-програм станом на 2026 рік з урахуванням кодів спеціальностей (CIP). Встановлено, що провідні позиції займають як елітні дослідницькі університети, так і великі державні заклади вищої освіти, які забезпечують масову підготовку фахівців у галузях науки, технологій, інженерії та математики.

Розглянуто графік еволюції STEM-програм у США, визначено основні етапи їх розвитку: від початкового формування в середині 20 століття до інтенсивного зростання у 21 столітті, спричиненого цифровізацією, розвитком штучного інтелекту та міждисциплінарними дослідженнями. Доведено, що кількість STEM-програм є важливим показником розвитку освітнього середовища, відображає рівень інноваційності університетів та їхню здатність адаптуватися до потреб ринку праці.

З педагогічної та наукової точки зору обґрунтовано, що сучасна STEM-освіта трансформується в міждисциплінарну систему, орієнтовану на формування компетентностей 21 століття у викладачів та учнів, критичного мислення та інноваційного потенціалу здобувачів освіти. Поєднання табличного та графічного аналізу дозволило сформувати цілісну картину структурних та динамічних характеристик розвитку STEM-освіти в США.

Результати дослідження можуть бути використані для вдосконалення освітньої політики України, розробки нових навчальних програм, а також проведення порівняльних досліджень та адаптації передового досвіду STEM-освіти в міжнародному контексті.



Ключові слова: *STEM-програма, вища освіта, університет, освітні програми, Класифікації навчальних програм, Сполучені Штати Америки, Україна.*

Introduction. In the current conditions of global transformations, digitalization and intensive development of the scientific and technological sphere, the higher education system is undergoing significant changes, which necessitate a rethinking of its goals, content and organizational models. A special place in these processes is occupied by STEM education (Science, Technology, Engineering, Mathematics), which is a key factor in the formation of human capital and ensuring the innovative development of society. In this context, the experience of the United States of America is extremely important, since it is this country that has formed one of the most effective models of integration of education, science and technology.

The formation of STEM education in the USA has a long history, covering the period from the middle of the twentieth century to the present (Batyuk, 2025; Cheng & Kinoshita, 2024; Li & et al., 2020; Bentley, 2021; Kelley & Knowles, 2016; Marginson & et al., 2013; Sanders, 2009). During this time, significant changes have occurred in the structure of educational programs, the content of training, and approaches to training specialists. From the initial dominance of individual disciplines (mathematics, physics, engineering), the system has gradually transformed into a comprehensive interdisciplinary model that meets the challenges of the modern knowledge economy. This evolution is clearly visible in the dynamics of the growth of the number of STEM programs in the United States from 1940 to 2026 (Batyuk, 2026). From a scientific and pedagogical point of view, the number of STEM programs is an important indicator of the development of the educational environment. It reflects the level of diversification of educational offers, the degree of integration of new knowledge into the educational process, and the ability of universities to adapt to changes in the labor market. The growth in the number of programs indicates the expansion of educational opportunities for students, the formation of individual educational trajectories, and the development of an interdisciplinary approach to learning.

An important tool for analyzing the structure of STEM education in the United States is the Classification of Instructional Programs system, developed by the National Center for Education Statistics (Classification of Instructional Programs, 2026). This system provides a standardized classification of educational programs, which allows for their comparative analysis, determination of the sectoral structure of specialist



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training, and assessment of the dynamics of the development of educational areas. The use of CIP is particularly relevant in the context of STEM education research, since it allows for quantitative and qualitative identification of relevant programs by field of knowledge in the United States of America.

In this context, the analysis of US universities ranked by the number of implemented STEM programs is of particular scientific significance, which makes it possible to assess the institutional capacity of higher education institutions to provide training for specialists in various fields of science and technology. This approach allows not only to identify leaders in the field of STEM education, but also to identify patterns in the development of educational programs, their structural diversification and compliance with modern labor market challenges and creates a basis for identifying effective models of organizing STEM education, determining the prospects for its development and substantiating the possibilities of adapting the American experience in other educational systems.

Thus, the relevance of the study is due to the need for a comprehensive analysis of the development of STEM education in the USA, taking into account historical dynamics, the institutional structure of universities and classification approaches to educational programs. This approach allows not only to systematize the current state of STEM education, but also to identify key trends in its development, which is important for the formation of effective educational policy and conducting further scientific research.

Aim and tasks. The purpose of the article is to conduct a systematic analysis of US universities ranked by the number of implemented STEM programs in the period 1940–2026, using the CIP classification system, as well as to determine the main trends in the development of STEM education in historical and modern perspectives.

To achieve this goal, the following tasks are envisaged:

1. To analyze the evolution of STEM education in the US in the period 1940–2026.
2. To reveal the essence and possibilities of using the CIP system for classifying educational programs.
3. To rank US universities by the number of STEM programs, taking into account CIP codes.
4. To identify the main trends in the development of STEM education based on graphical and tabular analysis.
5. To substantiate pedagogical and scientific conclusions regarding the transformation of educational models in the STEM field.



The object of the study is the US higher education system, and the subject is the structure and dynamics of STEM educational programs in leading universities.

The proposed study is aimed at a comprehensive understanding of the development of STEM education as an important factor in the innovative development of society, which allows for the formation of scientifically sound approaches to improving educational systems in a global context.

Methods of research. The methodological basis of the study is a complex of general scientific and special methods that provide a comprehensive analysis of the development of STEM education in the USA, in particular the process of ranking universities by the number of implemented educational programs in the period 1940–2026. The following methods were used in the study: theoretical research methods (methods of analysis, synthesis, generalization and systematization of scientific literature were applied to study the current state of development of the problem of STEM education, determining its essence, structure and main approaches to the classification of educational programs, which allowed to form the theoretical basis of the study and substantiate the conceptual and categorical apparatus); historical and pedagogical research method for analyzing the evolution of STEM education in the USA in the period 1940–2026, which made it possible to identify the main stages of its development, identify key trends and factors influencing the transformation of educational programs; a systemic approach (used to consider STEM education as a holistic multi-level system that includes educational programs, universities, public policy, and the labor market, which ensured the complexity of the study and the possibility of establishing relationships between its components); a comparative research method for comparing US universities by the number of STEM programs, which allowed them to be ranked and identify institutional features of the development of educational programs; a statistical research method for processing quantitative data on STEM programs, their distribution by universities, and development dynamics over time, which allowed us to substantiate the results of the study on the basis of empirical data; a classification analysis method based on the use of the Classification of Instructional Programs system, which provides a standardized grouping of educational programs by fields of knowledge and made it possible to identify STEM directions, carry out their structural analysis, and make a correct comparison between universities; a graphical research method for visualizing the results of the study, in particular, constructing a graph of the evolution of STEM programs in the USA for the period 1940–2026, which allowed us to clearly reflect the dynamics of the development of educational programs and identify the main trends in their growth; a tabular research



method for presenting the results of the ranking of US universities by the number of STEM programs, taking into account CIP codes; a bibliometric research method for analyzing scientific publications in the Scopus and Web of Science databases, which allowed us to determine the level of research on the problem, the main scientific trends and directions for the development of STEM education.

Results. The problem of the development of STEM education in the USA is the subject of active research in modern scientific discourse, covering pedagogical, socio-economic, institutional and technological aspects. In the scientific literature, STEM education is considered as an integrated educational model aimed at the formation of interdisciplinary competencies, innovative thinking and the ability to solve complex practical problems. An analysis of scientific publications shows that research on STEM education in the USA can be conditionally divided into several thematic areas:

- a) theoretical foundations of STEM education;
- b) educational policy and state regulation;
- c) institutional development of universities;
- d) pedagogical technologies and teaching methods;
- e) bibliometric and statistical research on STEM.

A significant contribution to the development of the theoretical foundations of STEM education in the USA was made by such researchers as Mark Sanders (Sanders, 2009), Hui-Hui Wang et al. (Wang & et al., 2011), Rodger W. Bybee (Bybee, 2013), John Ritz et al. (Ritz & et al., 2015), Todd R. Kelley and J. Geoff Knowles (Kelley & Knowles, 2017), Brendan Bentley (Bentley, 2021), Lijun Cheng and Riew Kinoshita (Cheng & Kinoshita, 2024) and others. In their works, STEM education is considered as a new educational paradigm that integrates natural sciences, technology and engineering into a single learning system.

A significant number of scientific publications are devoted to the analysis of STEM education in the United States in the context of educational policy. In particular, studies by the National Science Foundation emphasize the importance of state support for STEM areas, which contributes to the development of an innovative economy and the training of highly qualified personnel (Batyuk, 2025). Researchers emphasize that the effectiveness of STEM education depends on the ability to integrate theoretical knowledge with practical skills. In this context, the use of digital technologies, laboratory research and innovative educational environments in higher education institutions is of particular importance. The works of American researchers emphasize the role of universities as key institutions of the STEM ecosystem. In particular, leading universities, such as the Massachusetts Institute of Technology (Massachusetts Institute



of Technology, 2026), Stanford University (Stanford University, 2026) and the University of California, Berkeley (UC Berkeley, 2026), are considered as centers of innovation generation and development of new technologies. A separate area of research is devoted to the analysis of the structure of STEM education through the use of classification systems, in particular the Classification of Instructional Programs (New CIP Codes Added to DHS STEM Designated Degree Program List, 2023, 2026). Scientific works emphasize that CIP is a key tool for standardizing educational programs and provides the possibility of their quantitative analysis.

From a pedagogical point of view, STEM education is considered as an innovative learning model based on the integration of disciplines, active learning and the use of modern technologies, highlighting the following key approaches:

- Problem-Based Learning;
- Project-Based Learning;
- Inquiry-Based Learning;
- Interdisciplinary approach.

The issue of quantitative analysis of STEM programs in the US higher education system is a relatively new but important area of scientific research that is actively developing. In modern literature, this area is considered at the intersection of pedagogy, educational policy, educational economics and scientometrics, demonstrating that interest in quantitative ranking of universities by STEM indicators has increased significantly after 2000, which is associated with:

- the development of the knowledge economy;
- the digitalization of education;
- global competition of universities;
- the growing role of innovative technologies.

Studies show that the USA occupies a leading position in the formation of STEM scientific discourse: about 70–75% of publications in leading journals belong to American researchers. This confirms the dominant role of American universities in the development of STEM education (Batyuk, 2024).

In the modern period of globalization and digitalization, research focuses on the growth of the number of STEM programs; interdisciplinarity; digital technologies; artificial intelligence. According to analytical reports, the share of STEM degrees in the United States has increased from approximately 29% in 2000 to more than 35–40% in the 2020s, which indicates an intensive expansion of educational programs (Batyuk, 2024).



An analysis of scientific publications allows us to identify several main approaches to the study of university rankings by STEM programs:

1) *Institutional approach*. In this direction, universities are considered as centers for the generation of STEM programs. Studies analyze the number of educational programs; the diversity of CIP codes; the level of interdisciplinarity. Leading universities such as Massachusetts Institute of Technology, Stanford University, University of California, Berkeley occupy leading positions in most publications.

2) *Quantitative (scientometric) approach*. This approach is based on NCES statistical data; the use of CIP codes; analysis of the number of programs and degrees. Researchers emphasize that the classification of programs is carried out by the universities themselves, which creates a certain variability in the data.

3) *Bibliometric approach*. Modern works actively use tools for analyzing scientific publications, in particular VOSviewer. Bibliometric studies show an increase in the number of publications after 2010; the dominance of digital learning, AI, data science topics; a high level of interdisciplinarity.

4) *The role of public policy and institutions*. Statistics show a significant increase in the number of students in STEM fields and the expansion of master's programs in 2020–2026. The main conclusions of the publications:

- state funding stimulates the expansion of STEM programs;
- universities adapt educational programs to the needs of the economy;
- there is an integration of education and scientific research.

5) *Pedagogical aspect of research*. STEM programs are considered a tool for forming 21st century competencies; a means of integrating theory and practice; the basis of innovative learning. Studies emphasize that the growth in the number of STEM programs increases the accessibility of education; contributes to the individualization of learning; forms new educational trajectories. At the same time, there are problems, namely: unequal access to STEM education; shortage of teachers; high level of student dropout.

Scientific gaps in the main approaches to research on STEM programs and STEM education are associated with:

1. The absence of long-term (1940–2026) comprehensive research.
 2. Limited use of CIP for ranking universities.
 3. Insufficient integration of graphical (dynamics) and tabular (structure) analysis.
 4. Insufficient comparative analysis between universities of different types.
- Thus, the analysis allows us to highlight the following key problems:



- 1) Scientific interest in STEM education in the USA has a steady growth trend.
- 2) Ranking universities by the number of STEM programs is a new but promising area of research.
- 3) The Classification of Instructional Programs system is a key tool for quantitative analysis of educational programs.
- 4) Leading US universities form the core of STEM education and determine global educational trends.
- 5) Further research should be aimed at a comprehensive analysis of the structure and dynamics of STEM programs.

The generalized ranking of US universities by the number of STEM programs and areas is a complex analytical construct that reflects not only quantitative indicators of educational activity, but also deep transformations of the higher education system. Unlike classical rankings based on scientific productivity or academic reputation, this approach involves assessing the institutional ability of universities to generate and scale educational programs in the field of STEM.

The methodological basis of such a ranking is the number of accredited STEM programs (bachelor's, master's, PhD); the level of interdisciplinarity; the dynamics of the expansion of educational areas; the volume of funding for research and educational innovations; the integration of education with scientific and industrial ecosystems.

The formation of the modern ranking of US universities by the number of educational STEM programs is the result of a long historical evolution, which is conventionally divided into five key stages.

Stage I. Pre-war and military-industrial stage (1940–1960).

During this period, the development of STEM education was closely linked to the military-industrial needs of the United States (Batyuk, 2025). Leading technical universities focused on training engineers, physicists, and specialists in the field of applied sciences. It was then that the foundation of future leaders of the rating was laid - universities with a powerful engineering school.

Stage II. Space Race and scientific expansion (1960–1980).

After World War II and in the conditions of the Cold War, the US Government allocated additional funds for scientific developments, and state funding for science increased. Scientific works of this period emphasized the role of universities as centers for training scientists. During the Space Race (Mann, 2023), the number of STEM programs grew rapidly. Federal investments have stimulated the development of physics, mathematics, and aerospace engineering (Batyuk & Zhernovnykova, 2025). Universities are beginning to actively expand their curricula, which is becoming the



first large-scale stage of STEM diversification (Batyuk, 2025). By the 1970s, US public universities began to dominate the training of STEM specialists, providing over 70% of doctoral degrees in science and engineering.

Stage III. The Digital Revolution (1980–2000).

The emergence of computer science significantly transformed the educational landscape. Universities such as the University of Illinois Urbana-Champaign became centers of innovation related to the development of computer technology and networks, including early Internet projects (Batyuk, 2025). This led to an exponential growth in the number of STEM programs (Batyuk, 2024). During this period, a systematic approach to the classification of educational programs was formed. It was then that the Classification of Instructional Programs (CIP) system was developed, which became a key tool for analyzing educational programs. Studies emphasize that its implementation allowed: to standardize educational areas; to conduct statistical analysis of programs; to conduct comparative research of universities.

Stage IV. Integration of STEM as an educational paradigm (2000–2015).

At the beginning of the 21st century, STEM is transformed from a set of disciplines into a holistic educational concept (Zhan, 2022). National initiatives, such as the National Math and Science Initiative, are emerging to scale up STEM education (Batyuk & Zhernovnykova, 2025). Universities are beginning to actively integrate interdisciplinary programs (Batyuk, 2026; Li & et al., 2020).

Stage V. The era of innovation and interdisciplinarity (2015–2026).

The current stage is characterized by the rapid development of new areas, such as artificial intelligence, bioengineering, robotics. For example, the launch of new majors such as robotics at leading universities demonstrates a trend toward the formation of new academic disciplines (Batyuk & Masych, 2025).

There is no single, accurate historical ranking of US universities by the number of STEM programs implemented from 1940 to 2026 in open sources, as universities have different program classifications and they are constantly changing (Teichler, 2011; Hallinger & Kovačević, 2019). Therefore, scientific research usually uses proxy indicators:

- number of STEM majors and departments;
- number of STEM graduates;
- size of research programs and laboratories.

In the United States, all educational programs are systematized using a standardized federal classification known as the Classification of Instructional Programs (CIP), which is developed and maintained by the National Center for



Education Statistics (NCES). This system is a universal tool for identifying, comparing, and analyzing educational programs within the national system of higher education in the United States, ensuring the unity of statistical accounting, research activities, and educational policy. The CIP classification was first introduced in 1980 as a response to the need for standardization of educational data in the rapidly growing system of American higher education. Subsequent updates (1990, 2000, 2010, 2020) reflected structural changes in science, technology, and the labor market (United States Department of Education, National Center for Education Statistics, 2003; New CIP Codes Added to DHS STEM Designated Degree Program List, 2023, 2026). Thus, the CIP is a dynamic system that adapts to the transformations of the educational and scientific space, including the emergence of new interdisciplinary fields such as data science, cybersecurity, and artificial intelligence.

Structurally, the CIP is based on a hierarchical principle, which implies a multi-level organization of educational programs (Berry & et al., 2023). Each specialty has a six-digit code, where:

- the first two digits indicate a broad field of knowledge (for example, 14 - engineering, 11 - computer science, 26 - biological sciences);
- the next two digits define a subfield;
- the last two digits specify the specialization.

For example, code 11.0701 corresponds to the specialty "Computer Science", and 14.1901 corresponds to the specialty "Mechanical Engineering". Such detailing allows not only to identify the program, but also to analyze its place in the broader structure of knowledge. It is important to emphasize that CIP performs not only a classification, but also an analytical function. It is widely used by US federal agencies, in particular the U.S. Department of Education, to collect statistical data, form educational policy and forecast labor market needs. Thanks to CIP, data comparability between universities, states and time periods is ensured, which is critically important for conducting educational research and international comparisons.

CIP is of particular importance in the context of the development of STEM education. In the USA, the concept of STEM is defined precisely through the corresponding groups of CIP codes, which include Engineering (14), Computer Science (11), Biological & Biomedical Sciences (26); Mathematics & Statistics (27), Physical Sciences (40), as well as a number of interdisciplinary areas (in particular 30.x, 15.x, etc.), which reflects the current evolution of STEM (DHS STEM Designated Degree Program List, 2024; New CIP Codes Added to DHS STEM..., 2026). Therefore, the number of STEM programs = the number of programs with



STEM-CIP codes. This allows for accurate identification of STEM programs and their quantitative analysis at the university, state, and national levels.

Thanks to CIP, it became possible to form such tools as the list of STEM specialties, which is used by the U.S. Department of Homeland Security to determine programs that give the right to extended employment for international students (STEM OPT). This demonstrates that CIP has not only academic, but also applied significance, influencing migration policy and global student mobility. In addition, the CIP system is actively used in bibliometric and scientometric studies. It allows you to group publications, educational programs and scientific areas according to a single classification basis, which is a necessary condition for building knowledge maps, in particular in the VOSviewer software (Waltman & et al., 2010). Thus, CIP is an important tool for integrating educational and scientific data.

In today's conditions of digitalization of education, the role of CIP is growing even more. New codes are emerging that reflect the development of such areas as artificial intelligence; big data and analytics; cybersecurity; interdisciplinary STEM research. This indicates that the classification is not static, but is constantly updated in accordance with the challenges of the 21st century. At the same time, such dynamism creates certain challenges for scientists, teachers and educators, which are associated with the need to harmonize data from different years. As a result, the CIP system is a fundamental element of the institutional architecture of higher education in the United States. It ensures the standardization of educational programs; the possibility of quantitative analysis of STEM education; integration of education, science and the labor market; support for state educational policy. Thus, the use of CIP as an analytical tool allows not only to systematize educational programs, but also to gain a deeper understanding of the structural transformations of modern higher education, which is especially important in the context of global competition and the development of STEM ecosystems. Table 1 presents a generalized ranking of US universities with the largest number of educational programs in STEM specialties and areas by 2026.



Table 1.

US Universities Ranked by the Number of STEM Programs (2026) with CIP Codes.

<i>University</i>	<i>Type of educational institution</i>	<i>Estimated number of STEM programs*</i>	<i>Main STEM-CIP codes</i>	<i>Main STEM fields</i>
Massachusetts Institute of Technology	Technical	200+	14, 11, 26, 27, 40, 30.7	Engineering, AI, Physics, Biotechnology
Stanford University	Research	180-220	11, 14, 26, 30.7	Computer science (IT), Robotics, Bioengineering
University of California, Berkeley	Public	170-210	14, 26, 40, 27	Engineering, Data science, Materials Science, Physics
University of Michigan	public	160-200	14, 11, 26, 30.7	Robotics, Biomedicine, AI
Georgia Institute of Technology	technical	150-190	14, 11, 15, 30.7	Aerospace, IT, Industrial engineering
Carnegie Mellon University	technological	140-180	11, 14, 30.7	Computer science, Robotics, AI
Purdue University	technical	140-170	14, 15, 26	Aviation, Mechanical engineering, Nuclear engineering
The Pennsylvania State University	public	140-170	14, 11, 26, 15, 30.7	Materials science, Engineering
Arizona State University	public	140-170	11, 14, 26, 30.7	Sustainability engineering, Space science
The University of Texas at Austin	public	130-160	14, 11, 26	Engineering, agriculture, IT, Oil and gas engineering
Texas A&M University	public	130-160	14, 01, 26	Energy, Engineering, Agricultural sciences
University of Florida	public	130-160	14, 26, 11, 30.7	Engineering, Space technology
University of Washington	public	120-150	11, 26, 27	AI, Data science, Medicine, Oceanology
University of Illinois Urbana-Champaign	technical	120-150	14, 11, 40	Electrical engineering, Computer engineering
University of California, San Diego	research	110-140	26, 11, 14	Bioengineering, Oceanography
Columbia University	private	100-130	14, 26, 27	Applied sciences
Harvard University	private	90-120	26, 27, 40	Biomedicine, Nanotechnology
California Institute of Technology	specialized	80-100	40,12,27	Physics, Space

*The assessment includes bachelor's, master's and PhD programs in STEM.



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Based on the historical and institutional analysis, several groups of universities can be distinguished that form the core of the ranking.

1. *Global leaders in STEM education*. This group includes universities with the maximum number of STEM programs and a high level of innovation:

- Massachusetts Institute of Technology (Massachusetts Institute of Technology, 2026);
- Stanford University (Stanford University, 2026);
- University of California, Berkeley (UC Berkeley, 2026).

Their leadership is due to a combination of several factors: a large number of educational programs, a wide range of CIP codes and a high level of research activity. These universities cover almost all key STEM fields, including the latest trends, such as artificial intelligence, robotics and bioengineering, which largely explains their dominance in the ranking. Their key characteristic is the combination of a large number of programs with a strong scientific base and integration with industry.

2. *Large-scale public universities*. This group includes universities with a large number of programs and students:

- University of Michigan (University of Michigan, 2026);
- The University of Texas at Austin (The University of Texas at Austin, 2026);
- Texas A&M University (Texas A&M University, 2025);
- The Pennsylvania State University (The Pennsylvania State University, 2026);
- Arizona State University (Arizona State University, 2026);
- University of Florida (University of Florida, 2026);
- University of Washington (University of Washington, 2026).

These universities are characterized by a significant number of STEM programs, which is explained by their large-scale institutional structure, a large number of faculties and students, as well as extensive campus systems. An important feature of this group is the combination of classic STEM disciplines with new interdisciplinary directions, which is reflected in the widespread use of CIP codes of category 30.x. Their advantage lies in the mass nature of STEM education and a wide range of specializations. Arizona State University deserves special attention, which demonstrates an innovative approach to the development of STEM education. The university is actively implementing interdisciplinary programs focused on sustainable development, digital technologies and data analytics. This indicates a transition from the traditional STEM model to an integrated educational ecosystem, where the boundaries between individual disciplines are gradually blurred.

3. *Technological and specialized universities*.



- Georgia Institute of Technology (Georgia Institute of Technology, 2026);
- Carnegie Mellon University (Carnegie Mellon University, 2026);
- Purdue University (Purdue University, 2026).

These universities are characterized by a high concentration of STEM areas and specialization in high-tech industries, especially in the fields of engineering and computer science. Despite a somewhat smaller total number of programs compared to large universities, these institutions have a high specialization and a significant impact on the development of individual technological industries.

A separate category is made up of universities with a narrow but deep STEM specialization, in particular the California Institute of Technology (Caltech, 2026). Although the number of programs in such universities is relatively smaller, their contribution to the development of science is extremely significant. This demonstrates that a quantitative indicator does not always directly correlate with quality or scientific impact.

The addition of universities such as Pennsylvania State University and the University of Florida to the table more fully reflects the role of large multidisciplinary institutions in shaping the US STEM ecosystem. These universities have significant potential in the fields of materials science, biomedicine and engineering, and are also actively integrating new technological directions, which is confirmed by the expansion of the spectrum of CIP codes.

From a scientific and historical point of view, in the early stages (1940–1960), universities were dominated by engineering programs (CIP 14), which were associated with the military-industrial complex. In the 1980s, there was a rapid growth of computer science (CIP 11), which became the basis of digital transformation. In the 2000s, biological sciences (CIP 26) gained active development, and in the last decade there has been a rapid growth of interdisciplinary directions (CIP 30.x), such as data science and artificial intelligence.

Thus, the analysis of the table allows us to conclude that the current leadership of universities in the STEM field is determined not only by the number of programs, but also by their structural diversity, interdisciplinary nature and ability to adapt to new technological challenges. The use of the CIP system provides a reliable methodological basis for such an analysis, allowing universities to be compared on a single classification platform.

According to Table 1:

1. Technical universities (MIT, Georgia Tech, Caltech, CMU) have the highest concentration of educational STEM specialties.



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2. Large public universities offer the largest number of different programs.

3. Many universities from this list are among the top 20 in terms of the number of STEM graduates in the USA, in particular Penn State, UC Berkeley, Texas A&M, Purdue, Arizona State.

4. The STEM leadership of the USA is also confirmed by world rankings, where MIT, Stanford, Harvard, Caltech occupy leading positions.

Thus, the largest number of STEM educational programs in the USA has historically been implemented in their educational programs by universities such as MIT, Stanford, UC Berkeley, Georgia Tech, Purdue, Texas A&M and Michigan, which is explained by their status as research universities, significant federal funding and cooperation with technology corporations. Among the key factors shaping the leadership of the implementation of STEM education in US universities, it is necessary to highlight:

1. *Federal support of the US government and funding for education.* Federal investments play a key role in the development of STEM programs, contributing to the creation of new educational courses and research centers.

2. *Integration of education and science.* Leading universities combine teaching with research, which allows creating new educational directions.

3. *Interdisciplinarity.* Modern STEM programs integrate different fields of knowledge, forming new educational models.

4. *Global competition of universities.* STEM education is considered a key factor in economic development and innovation in higher education.

In conclusion, Table 1 demonstrates that STEM education in the United States is developing according to the model of a scalable innovation ecosystem, where both elite research universities and large public institutions play a leading role. This confirms that effective STEM education is the result of synergy between the quantitative growth of programs, their qualitative diversification and the integration of science, education and industry.

The current stage of development of STEM education (2020–2026) is characterized by the exponential growth of educational programs; the development of digital technologies; the growth of demand for STEM specialists; the expansion of the STEM education market, which is demonstrating significant growth rates. There is also a strengthening of the role of universities as centers of innovation and technological development.

Figure 1 shows a timeline of the evolution of STEM educational programs in the United States from 1940 to 2026.



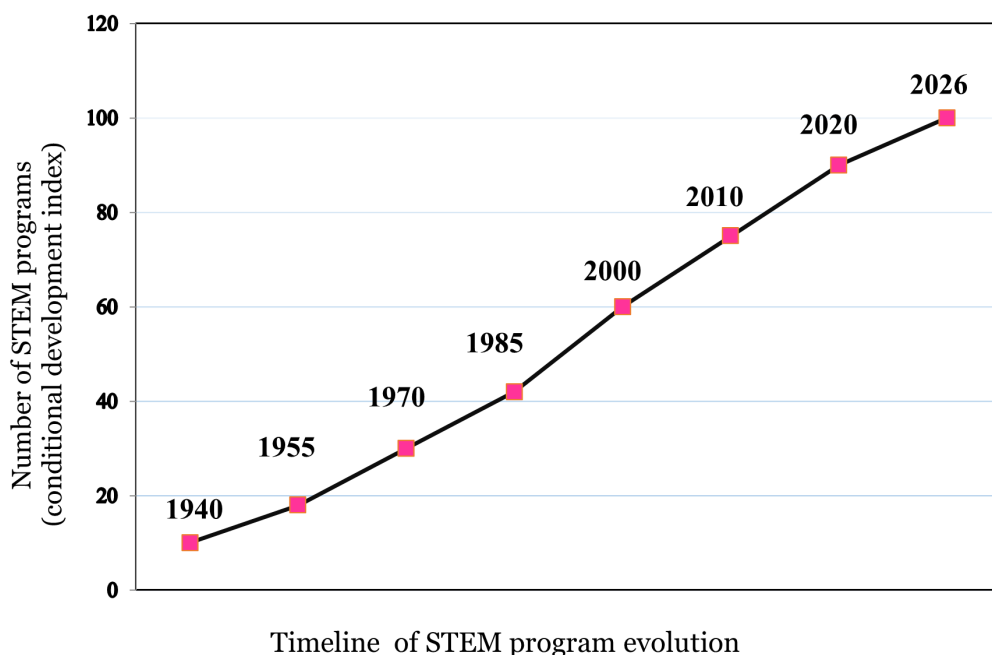


Figure 1. Timeline of the evolution of STEM educational programs in the United States (1940–2026).

At the initial stage 1940–1955 (see Figure 1), relatively slow dynamics are observed, which is explained by the dominance of highly specialized engineering and military-technical programs, focused mainly on the needs of the war economy of the Second World War and post-war reconstruction. At this time, STEM as an integrated concept had not yet been formed, and educational programs existed mainly within individual disciplines.

In the period 1955–1970, the graph demonstrates a noticeable acceleration of growth, which is directly related to the scientific and technological rivalry within the framework of the Cold War and the consequences of the Space Race (Mann, 2023). An important factor is the role of US federal policy, in particular the activities of the National Science Foundation, which since the 1950s and 1960s has invested in the creation of new curricula and educational models, which contributed to the institutional growth of STEM fields. The activation of state funding through the National Aeronautics and Space Administration (National Aeronautics and Space Administration, 2026) and the National Science Foundation (National Science



Foundation, 2026) stimulated the development of university programs in the fields of physics, mathematics, engineering and space technology.

The next stage 1970s–1990s is characterized by stable and more uniform growth. During this period, there is an institutionalization of scientific education, the expansion of engineering specialties and, most importantly, the emergence of new areas related to computer technology. The formation of computer science as an independent field has significantly influenced the structure of STEM education, which is reflected in the gradual increase in the curve of the graph.

In 1990–2010 there was a sharp increase in the number of STEM programs, which was due to the digital revolution, globalization of the economy and the transition to an information society. Universities are actively implementing programs in information technology, biotechnology and engineering of new materials. It was during this period that the modern understanding of STEM as an integrated educational paradigm was formed.

The most intensive development occurred in 2010–2026, when the graph demonstrates almost exponential growth. This is due to the implementation of national STEM strategies, the development of interdisciplinary programs and the rapid spread of such areas as artificial intelligence, data analysis, robotics and quantum technologies. Educational programs are becoming more flexible, integrated and focused on the innovation economy.

Thus, the graph of the evolution of STEM programs in the USA reflects the transformation from fragmented scientific and technical education to a comprehensive, interdisciplinary system that meets the challenges of the 21st century. The general trend indicates a steady growth in the role of STEM education as a key factor in the scientific and technological development of the state.

Discussion. The relevance of this study is determined by the need for a comprehensive analysis of the development of STEM education through a combination of quantitative (tabular) and dynamic (graphic) indicators. In particular, the table «US Universities Ranked by the Number of STEM Programs (2026) with CIP Codes» reflects the institutional distribution of educational programs; the figure «Timeline of the evolution of STEM educational programs in the United States (1940–2026)» demonstrates the historical dynamics of development; and descriptive analysis allows interpreting the data obtained from a pedagogical and scientific point of view.

The generalized ranking of US universities by the number of STEM programs is a reflection of the historical development of education; state policy and technological



progress. The leadership belongs to universities that have a wide range of programs; integrate education and research; actively implement innovations.

From a pedagogical perspective, the number of STEM programs in universities is an indicator not only of the educational offer, but also of the level of development of the educational environment capable of ensuring the formation of 21st century competencies. The increase in the number of programs indicates the diversification of educational trajectories, the integration of new knowledge and the adaptation of universities to the requirements of the labor market.

The figure «Timeline of the evolution of STEM educational programs in the United States (1940–2026)» for the period 1940–2026 demonstrates a gradual but uneven growth in the number of educational programs. The initial stage (1940–1960) is characterized by relatively slow development, which is explained by the limited number of educational areas and the dominance of classical sciences. However, since the 1960s, there has been an intensification of the development of STEM education, which is associated with state investments in science and education, as well as with the formation of an institutional research base.

Particularly intensive growth occurs in the period 1980–2000, which correlates with the development of information technologies and computer sciences. At this time, a new paradigm of education is being formed, focused on digital competencies. In the future (2000–2026), there will be an exponential growth in STEM programs, driven by the development of artificial intelligence, biotechnology, data science, and other innovative industries. At the same time, modern research confirms the growth of student participation in STEM fields and the increase in the number of educational programs, especially at the master's level.

A tabular analysis of US universities allows us to identify the structural features of the development of STEM education at the institutional level. Leading universities, such as the Massachusetts Institute of Technology, Stanford University, and the University of California, Berkeley, are characterized by the largest number of STEM programs and a wide range of CIP codes. This indicates their ability to provide comprehensive training for specialists in various fields of science and technology.

At the same time, large public universities, such as Pennsylvania State University, Arizona State University, and the University of Florida, play an important role in ensuring the mass availability of STEM education. Their activities are aimed at expanding access to education and training a large number of specialists for the national economy.



From a scientific point of view, the combination of tabular and graphical analysis allows us to form a holistic picture of the development of STEM education. The table reflects the structural (static) aspect, while the graph reflects the dynamic (evolutionary) aspect. Together, they create a comprehensive analysis model that allows us to:

- assess the scale of development of STEM programs;
- identify key stages of their evolution;
- identify leading universities and their role in the STEM ecosystem.

A comprehensive study of STEM education in the USA using the CIP classification system, tabular ranking of universities, and graphical analysis of the evolution of educational programs allows us not only to systematize existing educational practices, but also to determine strategic directions for the development of education in the context of global transformations. As a result, STEM education appears as a key element of the modern educational paradigm, ensuring the innovative development of society, and its analysis through the prism of quantitative and qualitative indicators opens up new opportunities for scientific research and educational reforms.

Conclusions. The combination of graphical (dynamic) and tabular (structural) data analysis, as well as the use of the Classification of Instructional Programs classification system, made it possible to achieve a high level of generalization and scientific validity of the research results, to form a holistic picture of the evolution, institutional features and pedagogical and scientific patterns of the development of STEM education in universities in the United States of America.

First of all, it was established that the development of STEM education in the USA has a clearly expressed evolutionary nature and occurs under the influence of external (socio-economic, political, technological) and internal (institutional, pedagogical) factors. Analysis of the figure «Timeline of the evolution of STEM educational programs in the United States (1940–2026)» showed that the number of educational programs grew unevenly, passing through several key stages. The initial period was characterized by relatively slow development, which was due to the dominance of traditional scientific disciplines and limited capabilities of educational systems.

The next stage (1960–1980) is associated with a significant increase in the number of STEM programs, which was a consequence of active state support for science and education, as well as the development of research infrastructure. During this period, STEM education begins to take shape as a systemic phenomenon, rather



than a set of individual disciplines. The period 1980–2000 is especially significant, when there is a rapid development of information technologies, which led to the emergence of new educational programs in the field of computer science and programming. The most intensive stage of development of STEM education is observed in the 21st century (2000–2026), which is confirmed by a sharp increase in the number of educational programs. This is due to the development of digital technologies, artificial intelligence, biotechnology and interdisciplinary research. Thus, the evolution graph of STEM programs reflects not only quantitative growth, but also qualitative transformation of the educational system, moving from a disciplinary to an integrated model of learning.

From a pedagogical and scientific point of view, it has been established that the growth in the number of STEM programs is an important indicator of the development of the educational environment. It indicates the diversification of educational trajectories, the expansion of opportunities for individualization of learning and the integration of the latest scientific achievements into the content of education. At the same time, it is important to note that quantitative growth should be accompanied by qualitative improvement of educational programs, in particular, the introduction of innovative pedagogical technologies, the development of critical thinking and the formation of interdisciplinary competencies.

Analysis of the table «US Universities Ranked by the Number of STEM Programs (2026) with CIP Codes» allowed us to identify key patterns in the development of STEM education at the institutional level. In particular, it was found that the leading positions are occupied by universities with a high level of research activity and a wide structural diversification of educational programs. These include institutions such as the Massachusetts Institute of Technology, Stanford University and the University of California, Berkeley. Their leadership is explained not only by the number of programs, but also by the ability to integrate different fields of knowledge and implement innovative educational approaches.

At the same time, a significant role in the development of STEM education is played by large public universities such as Pennsylvania State University, Arizona State University and the University of Florida. Their contribution is to ensure the mass availability of STEM education, the accessibility of educational programs and the training of a significant number of specialists for the economy. This allows us to conclude that there is a two-component model for the development of STEM education in the USA:

- elite research universities – as centers of innovation;



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– large public universities – as the basis for mass training.

An important result of the study is the confirmation of the effectiveness of using the Classification of Instructional Programs system as a tool for classifying and analyzing educational programs. Thanks to CIP, it became possible not only to standardize educational areas, but also to carry out their quantitative comparison, determine the structure of STEM education and identify trends in its development. Of particular importance is the growing role of interdisciplinary programs (CIP 30.x), which reflect modern trends in the integration of science and technology.

The combination of tabular and graphical analysis allowed us to form a comprehensive model for the study of STEM education. The table reflects a static cross-section of the system (the structure of programs and their distribution among universities), while the graph demonstrates the dynamics of development in time. This approach is methodologically sound and can be recommended for further research in the field of educational science.

From a pedagogical point of view, the results of the study indicate the transformation of the educational paradigm from the traditional subject model to a competency-based and interdisciplinary one. STEM education is becoming not only a set of academic disciplines, but also a holistic system for the formation of innovative thinking, the ability to solve complex problems and adapt to rapid changes.

It has been established that modern STEM education in the USA functions as an innovative ecosystem based on the interaction of universities, the state and business. Such a model ensures the effective integration of education, science and practice, promotes the development of innovations and increases the country's competitiveness at the global level.

The practical significance of the results obtained lies in the possibility of their use for improving educational policy, developing new curricula, as well as for conducting comparative research in an international context. The application of the obtained conclusions for the modernization of the education system in Ukraine taking into account the best practices of the USA is especially relevant.

Prospects for further research include an in-depth analysis of interdisciplinary STEM areas; studying the impact of digital technologies on the educational process; developing models for integrating STEM education in different countries; studying the quality of educational programs along with their quantitative characteristics.

Thus, the results of the study confirm that STEM education is a key factor in the development of modern society, and its effectiveness is determined by a combination of the quantitative growth of educational programs, their qualitative diversification,



and institutional support. The use of the Classification of Instructional Programs system, the analysis of universities, and the study of the dynamics of program development allow us to form a scientifically sound basis for further research and educational reforms.

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