DOI https://doi.org/10.51647/kelm.2022.8.6

PROBLEMY EDUKACJI STEM

Iryna Nikitina
starszy wykładowca Katedry Stosunków Międzynarodowych i Dyscyplin Społeczno-Humanistycznych
Dniepropetrowskiego Państwowego Uniwersytetu Spraw Wewnętrznych (Dniepr, Ukraina)
ORCID ID: 0000-0003-3767-7034
N.I.P@i.ua

Tetyana Ishchenko
starszy wykładowca Katedry Stosunków Międzynarodowych i Dyscyplin Społeczno-Humanistycznych
Dniepropetrowskiego Państwowego Uniwersytetu Spraw Wewnętrznych (Dniepr, Ukraina)
ORCID ID: 0000-0002-3103-978X
ishchenkotatiana76@gmail.com

Adnotacja. Każdy naród, który dba o swoją przyszłość, musi zapewnić młodemu pokoleniu dobre wykształcenie. Ważne jest, aby dać im umiejętności i wiedzę, których będą potrzebować, aby odnieść sukces jako innowatorzy w XXI wieku. Artykuł analizuje główne aspekty strategii edukacji STEM, która zapewnia studentom w dużej mierze interdyscyplinarne podejście do nauczania. W artykule ujawniono zarówno zalety, jak i wady tego podejścia do nauczania. Zauważono również cechy metody edukacji STEAM. Wskazane są specyficzne praktyki stosowania szkoleń STEM/ STEAM w Stanach Zjednoczonych, Unii Europejskiej i w Ukrainie, określone przez edukacyjne i zawodowe programy szkoleniowe. Szczególny nacisk kładzie się na perspektywy tych podejść do edukacji. Współczesna edukacja STEM rozwija nie tylko umiejętności, takie jak krytyczne myślenie, rozwiązywanie problemów, myślenie wyższego rzędu, projektowanie, ale także kompetencje behawioralne, takie jak wytrwałość, zdolność adaptacji, współpraca, organizacja i odpowiedzialność.

Słowa kluczowe: nauka, technika, technika i matematyka, zasoby i materiały, rozwój zawodowy, doświadczenie w edukacji STEM/STEAM, podejście interdyscyplinarne.

CHALLENGES OF STEM EDUCATION

Iryna Nikitina
Senior Teacher of the Department of International Relations, Social and Humanitarian Sciences
Dnipropetrovsk State University of Internal Affairs (Dnipro, Ukraine)
ORCID ID: 0000-0003-3767-7034
N.I.P@i.ua

Tetyana Ishchenko
Senior Teacher of the Department of International Relations, Social and Humanitarian Sciences
Dnipropetrovsk State University of Internal Affairs (Dnipro, Ukraine)
ORCID ID: 0000-0002-3103-978X
ishchenkotatiana76@gmail.com

Abstract. Any nation who takes care about its future should provide the young generation with a good education. It is essential to provide them with the skills and knowledge they'll need to be successful innovators in a XXI century. The article analyzes the main aspects of a learning strategy STEM which provides students mainly with an interdisciplinary approach to learning. Both the advantageous and disadvantageous issues of this learning approach are revealed in the article. The peculiarities of STEAM learning method have also been emphasized. The article notes the specific practices of applying STEM/STEAM learning in the USA, European Union and Ukraine, specified by educational and professional training programs. Special emphasis is put upon the perspectives of these approaches to education. Modern STEM education promotes not only skills such as critical thinking, problem solving, higher-order thinking, design but also behavioral competencies such as perseverance, adaptability, cooperation, organization, and responsibility.

Key words: Science, Technology, Engineering and Mathematics, resources and materials, professional development, STEM/STEAM teaching experience, interdisciplinary approach.

ВИКЛИКИ STEM ОСВІТИ

Ірина Нікітіна
старший викладач кафедри міжнародних відносин та соціально-гуманітарних дисциплін
Дніпропетровського державного університету внутрішніх справ (Дніпро, Україна)
ORCID ID: 0000-0003-3767-7034
N.I.P@i.ua

Тетяна Іщенко
старший викладач кафедри міжнародних відносин та соціально-гуманітарних дисциплін
Дніпропетровського державного університету внутрішніх справ (Дніпро, Україна)
ORCID ID: 0000-0002-3103-978X
ishchenkotatiana76@gmail.com

Анотація. Будь-який народ, який дбає про своє майбутнє, повинен дати молодому поколінню добру освіту. Важливо надати їм навички та знання, які їм знадобляться, щоб стати успішними новаторами в XXI столітті. У статті аналізуються основні аспекти стратегії навчання STEM, яка забезпечує студентам переважно міждисциплінарний підхід до навчання. У статті розкрито як переваги, так і недоліки такого підходу до навчання. Також наголошено на особливостях методу навчання STEAM. Відзначаються специфічні практики застосування навчання STEM/STEAM у США, Європейському Союзі та Україні, визначені освітніми та професійними програмами підготовки. Особливий акцент зроблено на перспективах цих підходів до освіти.Сучасна STEM-освіта розвиває не лише такі навички, як критичне мислення, вирішення проблем, мислення вищого порядку, дизайн, але й поведінкові компетенції, такі як наполегливість, адаптивність, співпраця, організованість та відповідальність.

Ключові слова: наука, техніка, техніка та математика, ресурси та матеріали, професійний розвиток, досвід викладання STEM/STEAM, міждисциплінарний підхід.

Introduction. Modern aspects of are caused by changes in the society's attitude to education and science. In a modern and rapidly changing world that we are living today it is vitally important for our children to be prepare for it since they are young. It is more important than ever to be ready to solve problems of any kind. To do so they have to know how to get knowledge and skills to solve problems, make sense of information, and know how to gather and evaluate evidence to make decisions. What skills are necessary to do so? These are the kinds of skills that students develop in science, technology, engineering, math, computer science. These disciplines are collectively known as STEM.

Every nation urgently needs not just citizens, but highly-qualified workers, businessmen, engineers, craftsmen, managers and other professionals who can understand and solve some of the complex challenges of the present time and what is more important of tomorrow. Not to the least degree it is important to meet the demands of the dynamic workforce. For this purpose, we have to build students' skills, giving them content knowledge. Every child wherever he lives must have access to quality learning environments.

Foreign sources view STEM education as an interdisciplinary approach to learning that combines rigorous academic concepts with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that establish links between school, society, work, and the global enterprise and aims to equip students with critical thinking skills that will allow them to creatively solve problems and, ultimately, be in demand in the labor market (NSTA, 2022).

Analysis of recent research and publications. The problem and perspectives of STEM education system has been studied by mainly American and European researchers such as Fareed Zakaria, John Maeda, Sandy Buczynski and others. However, the issue of upgrading and modern practice of it using new approaches to education needs further studies. That is why there is a need to study the ways of improving the methods of education that have already existed to adapt the education system to modern challenges.

The purpose of the article. The main purpose of the study is to analyze the views on the essence of STEM education in the USA and European countries, to study their experience in this sphere, to find out the main peculiarities of STEAM education as its successor, as well as to determine the prospects for its application in the practice of institutions of higher education.

Main research material. STEM education (science, technology, engineering, and mathematics) is quite experiential learning strategy which provides students mainly with an interdisciplinary approach to learning and allows the application of knowledge and skills to be integrated through in-context projects or problems. There are a few advantageous of this approach as compared to the already existed one. Firstly, STEM education makes learning "real". Secondly, it gives students the opportunities to see the connection between the subject content they are studying. And finally, it provides with the application of that content irrelevant ways.

Nowadays it is not enough just to have the basic knowledge of the main subjects. The National Science Foundation states that we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past (NSF, 2007).

Previously the main focus of the education was on teaching children the most important skills, nowadays we find a shift to problem resolving and critical thinking approach. It became more important to create the atmosphere for innovative solutions to proposed challenges.

STEM education is designed to encourage students to pursue these subjects as well as innovation and research in their education and career paths. This focus will help prepare future generations to best handle our world's biggest problems (NSTA, 2022). At the same time STEM cannot and should not replace other subjects. Students need to learn the same concepts and skills in science and mathematics as they did before but keep in mind how to solve problems through engineering design challenges. Much is spoken today about STEAM, e.g. Sandy Buczynski highlights the interplay between art and science in an article titled "Communicating Science Concepts Through Art: 21st Century Skills in Practice": "There is a dynamic synergy between the visual arts and the natural sciences. For example, science relies heavily on individuals with visual-art skills to render detailed illustrations, depicting everything from atoms to zebras. Likewise, artists apply analytic, linear and logical thinking to compose and scale their work of art" (Buczynski, 2012: 29).

STEAM education is particularly important in the scientific disciplines as she implies: "The next generation of scientists will need to develop their communication skills through both traditional means of writing and speaking, as well as more artistic means including illustrating, animating, videography, cartooning and model building." (Nikitina, Ishchenko, 2022: 173)

What separates STEAM from traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. It teaches students computational thinking and focuses on the real-world applications of problem-solving.

STEM USA Practices. It should be noted, however, that American society in which stem education actually originated is divided into those who adopt a new form of education and those who believe that there are too many shortcomings in it.

Undoubtedly, STEM education has a number of strengths. Firstly, these developmental programs are highly practical and intellectually challenging, and allow students to develop independence from an early age. Secondly, they promote gender equality. This learning style provides equal opportunity and encouragement for both sexes. Finally, they provide a good job potential. It is believed that if students build a STEM foundation early in their lives, they will have virtually endless job opportunities.

But at the same time, voices against STEM education are increasingly being heard. Farid Zakaria, columnist for The Washington Post and author of In Defense of Liberal Education, published an article "Why America's Obsession with STEM Education is Dangerous" which received widespread resonance in the United States. He believes the humanities are under attack. For example, he cited several state governors who pledged not to spend taxpayer money on subsidizing the liberal arts, and therefore English and history, once very popular and respected, are now in steep decline (Zakaria, 2015).

Zakaria eloquently explains the merits of a liberal arts education: it teaches the students write clearly, express themselves convincingly, and think analytically. He turns the arguments of the country's leaders in defense of STEM education upside down: standard manufacturing jobs in the United States continue to be automated or outsourced, and specialist skills often become obsolete within a few years. Engineering is a wonderful profession, but the key additional skills you will also need are creativity, thinking outside the box, design, communication, and most of all, the ability to constantly learn and enjoy learning, and these are the gifts of liberal arts education.

Innovation is not just a technical issue, but a matter of understanding how people and society work, what they need and what they want. No matter how strong your math and science skills are, you still need to be able to learn, think, and even write. Zakaria argues that technology is changing education, making the best courses and classes in a wide range of subjects available to millions of people around the world. We are at the dawn of the greatest diffusion of liberal education in human history.

We seem to forget that innovation comes not only from new kinds of chemicals, but also because of humans. Innovations in science are always somehow or directly related to human experience. And human experience happens through interaction with art - for example, listening to music or watching a piece of art (Maeda, 2010). Art helps you see things in a less constrained space. But artists and designers expand the horizon of possibilities. Superior innovation comes from bringing divergent (the artists and designers) and convergent (science and engineering) together. According to some American scientists, an attempt to activate education only in the direction of science without the parallel development of Arts disciplines can lead to the fact that the younger generation will lose the skills of creativity. As a result, the state of Massachusetts, for example, has passed legislation requiring schools to be ranked not only by how well students perform on standardized tests, but also by how each school's curriculum encourages student creativity.

STEM EU Practices. European education system nowadays faces the need to increase the motivation of students towards studying STEM subjects and raise achievement in these areas (Nistor, 2018, Gras-Velazquez, 2018, Billon, 2018, Mihai, 2018).

In Europe the implementation of STEM has already taken place. However, STE(A)M education is still taking its very first steps. For example, in the German education system STE(A)M is implemented largely for kindergarten and pre-school. Primary, secondary and high school do not have STEAM yet. For more than 14 years, STEM education has been a central issue in Germany at civil society and political level. The Federal Ministry of Education and Research published the STEM Action Plan in 2019 which defined four main fields of action: STEM education for children and young people, STEM professionals, opportunities for girls and women in STEM, and STEM

in society. The aim of these measures is to secure skilled workers in Germany and to promote female employees in technical and scientific fields. It supports educational professionals in kindergartens with ideas and training to support and awaken interest for STEM education in children. Communication, creativity, critical thinking and collaboration are the main targets. But even in the area of STEM education, German secondary schools do not provide cross-curricular schooling (Schuberth, 2020).

France also provides various national and local municipal initiatives to promote STEM studies. For example, Sciences at School works to encourage extra-curricular science activities for secondary school students, including clubs and various projects. The EU has done much work on boosting education in STEM fields, coordinating several projects within France itself, such as the "J'aime les Sciences" programme which targets individual participation and performance in science within primary and lower secondary schools through personalized approaches that focus on student self-confidence and motivation to study STEM subjects. These have become quite popular, thought to improve students' cognitive skills, as well as non-cognitive abilities that enhance their ability to participate successfully in STEM study. Other programmes and awards are targeted at the promotion of STEM fields for women and girls to improve their experiences in these fields of education and, hopefully, encourage their pursuit of STEM-related careers (Roberts, 2013).

In Sweden STEM education is also suitable for early childhood where education should preferably be holistic, child-centered and problem based. The Swedish preschool is goal-directed with teachers having to provide favorable conditions for children's learning based on both content and pedagogical knowledge. The Swedish national curriculum for preschool states that education should be based on a holistic approach to children and the needs of children, in which care, development and learning from a whole should be considered. In both Sweden as well as in Spain, preschool has a long tradition in working thematically, and activities are never divided into school subjects. Consequently, we describe the teaching of integrated STEM 'disciplines' instead as integrated STEM 'content areas', when referring to the preschool setting.

The aim is to contribute to the physical, affective, social, and emotional development of children from a global approach, that is, the contents are organized in interrelated areas. The methodological approach to these areas should be based on the experience of children and on play, within an atmosphere of affection and trust that helps to enhance self-esteem and social integration. (Fridberg, 2022, Redfors, 2022, Greca, 2022)

STEM UA Perspectives. In Ukrainian education, one of the first impetus for the development of STEM was the order of the Ministry of Education and Science of Ukraine №188 of 29.02.2016 "On the formation of the working group on the implementation of STEM education in Ukraine." In February 2021, an action plan for the implementation of the Concept for the Development of Natural and Mathematical Education (STEM-Education) until 2027 was published (Nikitina, Ishchenko, 2022: 110).

The document defines a set of measures related to the formation and development of skills in research and engineering, invention, entrepreneurship, early professional self-determination and readiness for a conscious choice of a future profession, popularization of scientific, technical and engineering professions, dissemination of innovations in the field of education.

According to the action plan, during 2021-2022 it was planned to develop training materials and methodological recommendations for teachers to prepare applicants for education to participate in the PISA international educational study. During this period, it is also planned to update the standards of higher education in the field of knowledge "Education / Pedagogy" on the use of the latest pedagogical approaches to teaching and assessment, the practice of interdisciplinary teaching, methods and teaching aids that contribute to the development of research and inventive competencies.

By 2023 it was planned to develop:

– a series of video lectures for teachers of physics, mathematics and primary school STEM education;

– new content of STEM-education for students of general secondary education (state standards, standard educational and training programs of subjects and integrated courses, elective courses) and extracurricular education (curricula of clubs, sections and other creative associations).

During 2021-2025 it was planned to carry out research and preparation of recommendations using STEM-education methods in educational institutions.

The action plan also provides for:

– holding conferences, seminars, symposiums on the use of the latest methods of STEM education for pedagogical and scientific-pedagogical workers;

– holding seminars for heads of educational institutions on the introduction of STEM education, developing appropriate advanced training programs;

– conducting career guidance events for applicants for education in the format of the "Professions of the Future" projects, weeks to promote STEM education, etc.;

– advanced training of pedagogical and scientific-pedagogical workers on the use of the latest methods of STEM education;

– creation of new STEM centers and STEM laboratories, expansion of their activities, equipping science and mathematics classrooms in educational institutions;

– introduction and support of the scientific and technical direction of out-of-school education.

Unfortunately, our STEM Concept only repeats the standard Western ideas about STEM education, almost without taking into account the specific situation in Ukraine:

– Unsuitable level of material and technical support of educational institutions;

– Misunderstanding by all participants of the essence of education according to the new standards;
– Unpreparedness of teachers for fundamentally new equipment and teaching methods.

The Future of STEAM Education.STEM education is one of the latest ideas in education, but some people are unsure if the benefits outweigh the potential disadvantages. As with any educational system, we need to do some research before deciding which learning style is best for our children. Where the importance of humanitarian disciplines is minimized, and the time and budget devoted to them is cut, children, especially gifted ones, suffer greatly.

Those interested in improving STEM teaching in schools have good intentions. To the extent that such initiatives improve the offerings and opportunities available to all children, gifted students will benefit. However, if these efforts lead to the exclusion of other important disciplines from the curriculum, gifted children will suffer as the vital critical and creative thinking skills they need to succeed in school and in life become less accessible.

Conclusions. STEM education is one of the latest ideas in education, but some people are unsure if the benefits outweigh the potential disadvantages. As with any educational system, we need to do some research before deciding which learning style is best for our children. Where the importance of humanitarian disciplines is minimized, and the time and budget devoted to them is cut, children, especially gifted ones, suffer greatly.

Those interested in improving STEM teaching in schools have good intentions. To the extent that such initiatives improve the offerings and opportunities available to all children, gifted students will benefit. However, if these efforts lead to the exclusion of other important disciplines from the curriculum, gifted children will suffer as the vital critical and creative thinking skills they need to succeed in school and in life become less accessible.

Список використаних джерел:

1. A National Action Plan for Addressing the Critical Needs for U.S. Science, Technology, Engineering, and Mathematics Education System (2007). URL: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsb07114
2. Buczynski, S., Ireland, K., Reed, S., Lacanienta, E. (2012). Communicating Science Concepts through Art: 21st-Century Skills in Practice. Science Scope. Vol. 35 № 9 Jul 2012 P. 29–35.
3. Fridberg, M., Redfors, A., Greca, I. (2022). Spanish and Swedish teachers' perspective of teaching STEM and robotics in preschool – results from the botSTEM project. *International Journal of Technology and Design Education.* DOI: 10.1007/s10798-021-09717-y
4. Maeda, J. (2010). Innovation is when art meets science. *The Guardian.* URL: https://www.theguardian.com/technology/2010/nov/14/my-bright-idea-john-maeda
5. National Science Teachers Association (2022). Why is STEM Hard to Define? URL: https://www.invent.org/blog/trends-stem/stem-define
6. Nikitina, I. P., Ishchenko, T. V. (2022). Transforming Stem into Steam. *Publishing House "Baltija Publishing"*, P. 173–176. DOI: 10.30525/978-9934-26-228-9-47.
7. Nikitina, I., &Ishchenko, T. (2022). Implementation of Stem education system in Ukraine. *Scientific Journal of Polonia University*, 51(2), P. 108–114. DOI: 10.23856/5114
8. Nistor, A., Gras-Velazquez, A., Billon, N., Mihai, G. (2018). Science, Technology, Engineering and Mathematics Education Practices in Europe. Scientix Observatory report. URL: https://www.researchgate.net/publication/332189707
9. Roberts, K. (2013). STEM Education in France. *Literature Review.* URL: https://www.researchgate.net/publication
10. Schuberth, K. (2020). Steam education in Germany. URL: https://steamonedu.eu/news/steam-education-in-germany
11. Zakaria, F. (2015). Why America's obsession with STEM education is dangerous. *The Washington Post*. URL: https://www.washingtonpost.com/opinions/why-stem-wont-make-us-successful/2015/03/26/5f4604f2-d2a5-11e4-ab77-9646eea6a4c7_story.html

References:

1. A National Action Plan for Addressing the Critical Needs for U.S. Science, Technology, Engineering, and Mathematics Education System (2007). URL: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsb07114
2. Buczynski, S., Ireland, K., Reed, S., Lacanienta, E. (2012). Communicating Science Concepts through Art: 21st-Century Skills in Practice. Science Scope. Vol. 35 № 9 Jul 2012 P. 29-35
3. Fridberg, M., Redfors, A., Greca, I. (2022). Spanish and Swedish teachers' perspective of teaching STEM and robotics in preschool – results from the botSTEM project. *International Journal of Technology and Design Education.* DOI: 10.1007/s10798-021-09717-y
4. Maeda, J. (2010). Innovation is when art meets science. The Guardian. URL: https://www.theguardian.com/technology/2010/nov/14/my-bright-idea-john-maeda
5. National Science Teachers Association (2022). Why is STEM Hard to Define? URL: https://www.invent.org/blog/trends-stem/stem-define
6. Nikitina, I. P., Ishchenko, T. V. (2022). Transforming Stem into Steam. *Publishing House "Baltija Publishing".* P. 173–176. DOI: 10.30525/978-9934-26-228-9-47.
7. Nikitina, I., &Ishchenko, T. (2022). Implementation of Stem education system in Ukraine. *Scientific Journal of Polonia University*, 51(2), P. 108–114. DOI: 10.23856/5114
8. Nistor, A., Gras-Velazquez, A., Billon, N., Mihai, G. (2018). Science, Technology, Engineering and Mathematics Education Practices in Europe. Scientix Observatory report. URL: https://www.researchgate.net/publication/332189707
9. Roberts, K. (2013). STEM Education in France. *Literature Review.* URL: https://www.researchgate.net/publication
10. Schuberth, K. (2020). Steam education in Germany. URL: https://steamonedu.eu/news/steam-education-in-germany
11. Zakaria, F. (2015). Why America's obsession with STEM education is dangerous. *The Washington Post.* URL: https://www.washingtonpost.com/opinions/why-stem-wont-make-us-successful/2015/03/26/5f4604f2-d2a5-11e4-ab77-9646eea6a4c7_story.html