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# Organization of a STEM-oriented environment in higher education institutions

## Організація STEM-орієнтованого середовища у ЗВО

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**Abstract**

The article analyzes the meaning of "STEM education", revealing personal and social aspects. The main organizational forms and open online tools for implementing STEM education are shown. The most important functions and goals of the educational environment provided by Google services for the implementation and organization of STEM projects in higher education institutions and the most significant approaches used for the organization of STEM education are highlighted; the importance of the STEM-oriented approach in education is emphasized, for its implementation in education the mandatory use of educational e-platforms is emphasized. When implementing and creating STEM projects in higher education institutions, it is important and necessary to use information and communication technologies, and virtual and augmented reality technologies. Implementing a

**Анотація**

У статті проаналізовано зміст поняття «STEM-освіта», розкрито особистісний та соціальний аспекти. Показано основні організаційні форми та відкриті онлайн інструменти реалізації STEM-навчання. Виокремлено найвагоміші функції та цілі освітнього середовища, які забезпечують сервіси Google для впровадження та організації STEM проєктів у закладах вищої освіти та найсуттєвіші підходи, які застосовуються для організації STEM освіти; наголошено на важливості STEM-орієнтованого підходу в освіті для впровадження якого в освіту наголошено на обов'язковому використанні освітніх е-платформ. При впровадженні та створенні STEM-проєктів у заклади вищої освіти важливим і необхідним є використання інформаційно-коммунікаційних технологій, технологій віртуальної та доповненої

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STEM approach to education results in a fruitful and stimulating STEM-oriented environment. Through experimental research, the importance and necessity of organizing a STEM-oriented environment in institutions of higher education was revealed, and the ways of using STEM technologies in higher education with a view to the formation of professional skills were clarified. Methodological recommendations have been developed for the implementation of the STEM approach in the practice of the educational process, where it is necessary to organize a STEM-oriented environment in higher education institutions and create certain optimal conditions.

**Keywords:** STEM-oriented environment, institutions of higher education, STEM-oriented approach, STEM-education, students of higher education.

реальності. Впровадження STEM-підходу в освіту призводить до плідного та стимулюючого STEM-орієнтованого середовища. Шляхом експериментального дослідження розкрито вагомість і показано необхідність організації STEM-орієнтованого середовища у закладах вищої освіти та з'ясувано шляхи використання STEM-технологій у вищій школі з виходом на формування професійних навичок. Розроблено методичні рекомендації для реалізації впровадження STEM-підходу в практику навчального процесу де необхідним є організація STEM-орієнтованого середовища у закладах вищої освіти та створення певних оптимальних умов.

**Ключові слова:** STEM-орієнтоване середовище, заклади вищої освіти, STEM-орієнтований підхід, STEM-освіта, здобувачі вищої освіти.

## Introduction

The advent of the Internet has fundamentally changed society. It is necessary to shift the emphasis in education from memorizing information and performing routine mechanical tasks to preparing specialists for various tests for the formation of innovative skills of the 21st century: creative problem solving, effective cooperation, project management, making important decisions, achieving defined goals, perseverance, determination, directing their passions and talents to improve the lives of people and the world. STEM education, in this context, the implementation of which began in the USA in 2009 at the state level under the "Educate to Innovate" program, is a pedagogical innovation of the beginning of the 21st century (Polihun et al., 2019).

There is a need in modern conditions for mixed and distance learning: the organization of STEM education is necessary, to conduct work in the direction of technologies, natural sciences, art, technical creativity, and mathematics. This issue is also relevant because specialists in the labor market who possess modern key and professional competencies related to technical fields of knowledge and use integrated knowledge to solve tasks are in greater demand now. We see the significant advantages of STEM education, which opens up wider opportunities for those seeking education, and not only affects the simplification of the educational process since it is about independent learning under the guidance of a mentor and a practice-oriented approach to learning (Sharova et al., 2023).

We are witnessing a change in the learning environment that occurred during the 2020 coronavirus pandemic, which necessitated the transition to distance learning. This change, despite the challenges associated with technical skills and adaptation of a person to a new learning environment, opened up new opportunities in the implementation of elements of STEM education. The presence of platforms, online services, and free mobile applications are useful for creating innovative, original, and interesting classes on any topic provided by the educational program. This ensures the relevance of the study of the possibilities of software products and electronic tools in the implementation of elements of STEM education in classes in institutions of higher education in the conditions of modern education (Rudenko & Zaitseva, 2022).

Investigating the organization of a STEM-oriented environment specifically in higher education is important. The key aspects of the STEM approach in higher education are:

- integration into a single paradigm of the content and methodology of natural sciences, modern technologies, in particular information, engineering design, and mathematical tools;
- designing curricula and programs on an interdisciplinary basis;
- integrated learning according to certain topics, not individual disciplines;

- application of cognitive and social technologies, as well as transfer knowledge;
- training on real technical-technological, economic, and socially significant problems;
- emphasis on the complex formation of scientific and engineering thinking.

The problem of organizing a STEM-oriented environment in higher education institutions in both theoretical and practical aspects is insufficiently researched, which is reflected in the lack of a unified understanding of the essence of this process.

The urgency of solving the outlined problem is enhanced by the aggravation of several contradictions that characterize modern higher education in Ukraine, in particular:

- between social requirements for the saturation of the educational process with modern technologies and the unpreparedness of the education system for a quick correction of the value orientations of the average teacher for their use;
- between the fragmentation and separation of the study of individual disciplines in the professional training of specialists and the integrity and integration of scientific knowledge through the practice of STEM education;
- between the need to study and take into account the individual characteristics and preferences of education seekers and the traditionally depersonalized methods, forms, and means of their education;
- between the general global trend of gender equalization of the influence of women and men in engineering and technology and the too-slow imitation of this process in the higher education system of Ukraine.

Insufficient theoretical and practical study of the outlined problem, its social importance, and the presence of several contradictions in modern higher education led to the choice of the topic of the article.

**Literature Review**

At the beginning of the 21st century, the abbreviation "STEM" was first used by the American professor Georgette Yakman (2017), who is the founder of this direction in the educational space. Since then, "STEM" has become a buzzword in education, even though it is a controversial and complex concept. According to the researcher, "Science and technology are transmitted through engineering and art – all this is based on mathematical elements". Educational research has proven the effectiveness of STEM education in student learning (Gao et al., 2020) and the professional development of the individual (Shernof et al., 2017). Scientists outline features, define, and improve practical and theoretical aspects of implementing STEM education in the world. N. Polihun, K. Postova, I. Slipukhina, H. Onopchenko, & O. Onopchenko (2019) proposed, first of all, for gifted students of educational space, models of integration of informal and formal education, which may become the basis of transformational processes for education in general in the future. The ways of using engineering design and the scientific method in the construction of STEM educational events are revealed, methodical approaches to the organization of STEM projects are proposed, the features of the educational STEM environment are revealed, and the use of the STEM environment is demonstrated on specific examples.

To create and support a STEM-oriented educational environment of the N. Soroko, & I. Pylypchuk (2020) educational institution, Google services were considered. The requirements of users that take into account Google services are shown (providing opportunities in the online environment to conduct joint research for participants of STEM projects; using tools that ensure group work when working with documents of various formats; managing the distance educational process; monitoring the research process; data sets that embody the information of research that has already been conducted; to create space for other educational projects in the environment of special programs).

T. Sharova, S. Sharov, & B. Kreminskyi (2023) devoted their research to the review of educational online resources to organize STEM training for young people. Scientists highlighted the main approaches for organizing STEM/STEAM education; analyzed the benefits and reasons for the relevance of STEM education; and proved that the basis of STEM education is project activity, practical-oriented learning, and interdisciplinary approach; examples showed the implementation of STEM education when using electronic educational resources, massive open online courses, Google services.

The ways of using software products and electronic tools in the process of implementing elements of STEM education (Technology,

Science, Engineering, Mathematics, Arts) in classes in institutions of higher education in the conditions of online education were considered by N. Rudenko, & S. Zaitseva (2022). STEM education is presented by researchers as an integrated project approach that has a practical orientation in pedagogy. The capabilities of mobile applications (VivaVideo, Movavi Clips, InShot, FilmoraGo, InShot) for creating educational videos, free web services (Google Classroom, Google Meet, Google Calendar), and programs for implementing project tasks (Microsoft Publisher) were studied. The advantages of STEM education are described. S. Belbase, B. Mainali, W. Kasemsukpipat, H. Tairab, M. Gochoo, & A. Jarrah (2021) also discussed the advantages of STEM education in schools and institutions of higher education, proved that STEM education is an integrated project approach in pedagogy and has a practical orientation. In educational institutions, an analysis of Google's main services was carried out to introduce the STEM approach to education, which made it possible to offer teachers basic solutions for their use to support, organize, and manage the STEM-oriented educational environment of an educational institution.

J. Costley, & C. Lange (2017) also showed the benefits of using technology in STEM education (reducing cognitive load and improving students' learning motivation). The contents of the most popular educational online services and platforms, free mobile applications for creating original and interesting classes have been revealed by research; the role of software products in the formation of students' language skills and the enrichment of their vocabulary was investigated.

O. Zawacki-Richter, V. Marín, M. Bond, & F. Gouverneur (2019) showed the ways of use and proved the need for the use of artificial intelligence in education, which proves the upward trend of education, as it contributes to increasing the ability of students to study analytics and strengthens the competitiveness of a specialist in the future in the labor market. To implement a positive impact on the educational process of the STEM-oriented environment in institutions of higher education, it is important to introduce innovative technologies, in particular artificial intelligence, gamification in learning design, etc., teachers should teach students how to use the tools of the STEM-oriented environment in classes to improve their educational interest

***Purpose of the article***. To reveal the importance and show the necessity of organizing a STEM-oriented environment in institutions of higher education and to find out ways of using STEM technologies in higher education with a view to the formation of professional skills.

**Methodology**

The methodological principles of the research are leading provisions of the theory of scientific knowledge; general scientific principles of historicism, systematicity, and scientificity; conceptual provisions of pedagogical, psychological, and sociological sciences; ideas of comparative research experience based on the simultaneous study of pedagogical, socio-cultural and economic phenomena; philosophical and pedagogical ideas of the development of modern education.

Research methods were used to achieve the goal:

– theoretical: analysis, synthesis, comparison, systematization, generalization, – analysis of psychological and pedagogical sources to clarify the key concepts of the study; study of provisions, and concepts;
– empirical: questionnaires, pedagogical observation – to find out ways of using STEM technologies in higher education with a view to the formation of professional skills;
– a pedagogical experiment for scientific confirmation of the purpose of the research;
– methods of mathematical statistics – to check and process research results using the Spearman rank correlation coefficient and the Kolmogorov-Smirnov agreement criterion.

The purpose of the experimental work was to reveal the significance and prove the necessity of organizing a STEM-oriented environment in institutions of higher education and clarifying the ways of using STEM technologies in higher education with a view to the formation of professional skills.

We developed an anonymous questionnaire, which was used to understand the importance of organizing a STEM-oriented environment in higher education institutions and to find out ways of using STEM technologies in higher education with a view to the formation of professional skills.

The questionnaire contained closed-type and open-type questions.

Our method of studying educational technologies was to use the method of surveying teachers and students who implement forms of STEM education and various directions in education.

As a result of the experiment, 145 respondents were involved. We found out that out of all (145) respondents – 30% use STEM technologies in higher education to form professional skills.

The research was conducted online. Quantitative and qualitative analysis procedures were used to process empirical data.

For comparative analysis and generalization of data, to ensure the possibility of comparison of data, they are given in relative values (%).

The implementation of the pedagogical experiment was carried out in three stages: preparatory, main, and final.

At the preparatory stage, the purpose and tasks of the research were determined, the experimental plan was developed, methods of measurement and processing of results were selected, control and experimental groups were selected, and their homogeneity was checked.

At the main stage, an experiment was conducted.

At the final stage, the results of the experiment were analyzed, their reliability was confirmed, and conclusions were drawn about the pedagogical effect of the experiment.

Research relies heavily on the accuracy and reliability of the data. In the framework of research work, the quality of data collection and analysis not only adds weight to the research but also contributes to the formation of sound conclusions, which is the key to academic success.

The following digital data collection tools were useful in the study:

- Google Forms – a simple tool for creating surveys that allows you to collect data from respondents, create different types of questions, and collect answers in spreadsheets.
- SurveyMonkey – a modern survey tool that offers a wide range of customization options and analytical tools for analyzing the collected data.
- JSTOR, Google Scholar, and other academic search engines provide access to scholarly articles, books, and other academic resources that may be useful for literature review and theoretical data collection.
- Zotero or Mendeley – bibliography management programs that help organize research materials, store references, and format bibliographies and citations according to different citation styles.
- Microsoft Excel or Google Sheets – spreadsheets are useful for organizing and analyzing collected data when working with quantitative data.
- SPSS, R, or Python for more advanced data analysis, statistical analysis, and processing of volumes of data.

When determining the sample of subjects, the general specificity of the research subject was taken into account. The total sample size is 145 subjects, among whom are students of physical education. When forming the sample, the criteria of meaningfulness, representativeness, and equivalence were taken into account. The sample was formed by random selection using the technical procedure for calculating the selection step.

The reliability and validity of the obtained results, and the objectivity of their assessment were ensured by the methodological soundness of the initial positions and the qualitative mechanism for evaluating the quality under study, the use of a complex of complementary research methods, and the involvement of a group of respondents from a higher educational institution in the analysis of its results.

To assess the homogeneity of experimental and control data, statistical processing was performed using MS Excel and SPSS (Statistical Package for Social Science).

## Results and Discussion

**Concept of STEM education: personal and social aspects.** In an interdisciplinary and applied context, STEM education includes in its content integrated training of higher education students in such specialized disciplines as technology, mathematics, natural sciences, art, and technical creativity. The development of the motivation of students of higher education during the educational process will be facilitated by the use of STEM elements because the activity of the teacher will be aimed specifically at solving integrated research tasks (Kryvovyaz et al., 2023).

In a broad context, STEM education is an innovative pedagogical technology for the

development and formation of mental, cognitive, and creative qualities of higher education students, the level of which determines the competitiveness of an individual in the modern labor market.

As a process of external influence on a person, STEM has the following aspects:

- personal – acquisition of practical authentic experience of innovative activity;
- social – preparation for employment and further education by the requirements of the 21st century.

The STEM approach in the educational process involves the formation of "soft" skills defined in Framework P21 and makes it possible to cover the sphere of creative potential, combining research and innovation activities, creativity, and creating horizontal connections between society, fields of knowledge, and the surrounding world.

With this approach, the STEM teacher is an active developer of interdisciplinary educational programs. Based on the system of practical skills and scientific knowledge, he has:

- determine the sequence, volume, and content of training;
- to determine the degree and nature of the integration of knowledge from various Gnostic fields;
- choose methods, methods, and strategies to ensure the most expected pedagogical result;
- expand the content of one's own professional training;
- constantly raise the level of the profession.

Such activity is not limited to teaching one's own subject. What is important is the ability of the teacher to organize the educational process as a pedagogical interaction, which will be aimed at preparing the student to solve life-creating tasks, in personality development.

The development of STEM education requires didactic developments, scientific new research, and literate and educated young talents, ready to change and change the world (Polihun et al., 2019). Therefore, STEM is "a modern educational model that focuses on practice, encouraging independent learning, independent research, and creativity" (Rudenko & Zaitseva, 2022).

In our time, manual labor is being gradually displaced in favor of robotic labor, that is, preference is given to the use of computers and robots due to the rapid digitization, modernization, and technology of various industries.

The number of professions that can be replaced by robots in the future reaches 60%, which is a great challenge for society in the world. Due to constant progress, there is a shortage of technical and scientific personnel on a global scale and, as a result, there is a greater demand for them than for humanitarian specialties. Therefore, STEM education is relevant today, because it is precisely this that meets the challenges of society. STEM education resembles a bridge between skills, careers, and knowledge, which are important criteria for the formation of scientific and technical personnel (Kryvoruchko & Shukatka, 2023).

**Basic organizational forms and open online tools for the implementation of STEM education.**

For high-quality implementation of STEM education, it is necessary to use such basic organizational forms as:

- STEM project – educational and cognitive, group, game, or creative activity of students of higher education, involves the integration of three or more STEM disciplines, has a common goal, means, and methods of activity, and is aimed at achieving a common result;
- STEM classes – a form of organization of the educational process with a group of permanent students in a given period, which involves the integration of three or more STEM disciplines;
- STEM course – combining several STEM disciplines into a single academic discipline;
- STEM hackathon – a joint activity of higher education students with various interests in STEM fields who work on creating a new product or solving a given problem;
- STEM-quest is a search team game, the main principle of which is the step-by-step execution of previously prepared logical tasks aimed at obtaining a single final result from STEM disciplines (Polihun et al., 2019).

The implementation of STEM education in institutions of higher education requires teachers to develop, using the STEM approach, methods of conducting classes, systematic educational activities, and event scenarios using the necessary tools of the STEM approach, which is a special support for such an innovative

environment. The choice of tools to support and organize a STEM-oriented educational environment of a higher education institution, and teacher training is important for the use of STEM-approach tools in one's professional activities to improve the educational process of a higher school.

For high-quality system support of the STEM-oriented educational process of the higher school, it is necessary to use the services of the company Google – open online tools that offer a significant range of services to ensure the organization of such an environment.

The National Institute of Standards and Technology of the USA has proven that "cloud computing is an effective service for providing the user with on-demand access anywhere and anytime to the common computing resources of subjects of various human activities", which also applies to the educational process of a higher school, which can be provided in the interaction with the service provider synchronously or asynchronously with minimal management effort (Mell & Grance, 2011). With this approach, the services of the Google company became important – open online tools, which as early as 2014, on the initiative of researchers (Etherington (2014) and Magid (2014)), began to adapt Google tools in the field of education to the educational and teaching activities of users according to various educational problems (ensuring continuous communication between the teacher and the student; lack of opportunity for the student to study at the institution for various reasons, etc.) to ensure a convenient distance educational process. In 2015, Google announced that users of its services would share access to Google Classroom. Google Calendar has been integrated into Google Classroom. Google Apps Education Edition, designed for the education space, provides free educational services for educational institutions containing Google Apps tools supported by many devices for work in an educational environment. Google Apps provides an opportunity for educators to use sites developed by them for educational purposes, promotes the activation of students' cognitive activities, and provides access to various exercises in the cloud, tasks, etc.

To organize and support a STEM-oriented educational environment, Google Services has developed services that enable students to:

- for conducting STEM projects, create sites without using the HTML language;
- to ensure constant communication between STM project participants;
- compatible with teachers of various STEM fields to transfer and store data, conduct online lessons, and review them regardless of the user's location and at any time;
- recognize scanned photos and materials;
- create presentations, drawings, diagrams, and other documents in the cloud;
- keep a calendar of events of STEM projects;
- observe phenomena within STEM projects for conducting research;
- conduct online monitoring.

Google Classroom, Google Apps, Google Sites, Google Video, Google Docs, and Google Sites are such programs that support the cooperation of teachers, students of higher education, and stakeholders asynchronously and synchronously.

Teachers use Google Classroom as a management system for joint teaching of the curriculum, the use of joint activities, and the exchange of developments and materials. Google Classroom integrates with Google Docs, Google Drive, and Gmail. Thanks to this service, it is possible to organize flipped learning, distance learning, and project work to support a STEM-oriented educational environment of a higher education institution.

Google Apps includes functions such as processing spreadsheets, texts, presentations, and forms.

With the help of Google Sites and Google Video, students can jointly add images, documents, and videos, and create websites.

Google Classroom allows users to:

- create your course;
- share necessary educational material with students;
- to organize the registration of students for the course;
- organize student interaction;
- propose tasks for students;
- evaluate students' tasks and monitor knowledge.

**Functions and goals of the educational environment provided by Google services for the implementation and organization of STEM projects in higher education institutions.**

Within the framework of the implementation and organization of STEM projects in institutions of higher education, Google services provide the functions of the educational environment to provide higher education students with general educational resources, namely:

- websites and programs for creating flashcards and quizzes (Google Forms, Google Slides, Google Sites, etc.);
- Google Search, electronic libraries, and other electronic educational resources;
- tools for creating mental diagrams, diagrams, and maps (Google Suite + Lucidchart);
- services for group work (Padlet online board, Google Apps for Education), etc.

It is also important to use Google services for specific purposes of a STEM-oriented environment, for example:

- for research and familiarization of scientific concepts with the help of modeling and the use of educational models (Google Earth VR for topography, when studying historical and geographically important areas of the study of the Earth and its three-dimensional structure, etc.);
- applications and websites are necessary for studying robotics (Google Play offers the games "Robotics Engineering", "Robotics!", and "Industrial Robotics 3D");
- for photo analysis – Google services and applications (Google Lens, which helps the user to identify an object based on a neural network using visual analysis, collect information about the object depicted in the photo), etc.

The student of higher education chooses electronic educational resources according to the goals of the individual STEM project, the form (informal, formal, informal), and the level of education for which this project is designed.

Google services take into account the educational requirements of users, and students of higher education:

- data sets representing the information of already conducted studies;
- providing opportunities for STEM project participants to conduct collaborative research in an online environment;
- use of tools that create an innovative space for group work on documents of various formats;
- remoteness in managing the higher education process;
- monitoring of the research process;
- to create space for other educational projects – combined in the environment of special programs (Soroko & Pylypchuk, 2020).

**STEM-oriented approach in education.**

The STEM-oriented approach is one of the current directions of innovative development and modernization of humanitarian and natural-mathematical profiles, which contributes to the implementation of life tasks, when solving which the development and formation of the engineering and scientific thinking of a specialist takes place, that is, it is focused on the innovative solution of emerging problems in the present. Creating an appropriate innovative environment is one of the ways to introduce the innovative STEM approach into the educational process of higher education institutions.

The STEM environment of a higher education institution includes in its essence the internal (software and hardware component, administrative and organizational component, educational and methodological component, subject component) and external (scientific institutions of higher education, research organizations, state education management bodies, business structures, industrial enterprises, stakeholders, sponsors, interested parties) provision.

The goals of STEM education are:

- in creating an environment for improving the qualities of citizens of the 21st century, understanding STEM,
- in the development of human resources in engineering, technology, science, and mathematics.

So, the STEM approach is:

- educational strategy;
- inspiration for a transformational approach to education, innovations in education, and the development of society (Liao, 2019).

For the process of higher education to correspond to the concept of STEM, it is necessary to turn training towards the teamwork of the students of higher education themselves, to change the usual form of teaching, when the class takes place around a teacher of a higher school.

The teaching method of STEM education is based on the organization of creative experimental activities and practical activities. Such forms of organization of learning as learning through deliberate play, teaching by topics through innovative approaches, simulation of real experience, and clubs allow students to explore, ask questions, and solve problems. The more complex the games, which require more skills (problem-solving, social communication, etc.), the better the higher education students will be able to learn the new material.

STEM pedagogy provides higher education students with metacognitive and cognitive tools to explore innovative ways of creative problem-solving. Rapid social changes and scientific and technical achievements of today are interrelated with the globalized influences of modernity and require creative thinking from the student as an essential adaptive skill for further career. One of the most significant achievements of STEM education is that it promotes non-standard thinking, creates conditions for joint work that allows each student to share knowledge, ideas, and experience in class, and provides an atmosphere of innovation and creativity in society (Rudenko & Zaitseva, 2022).

**Use of educational e-platforms for effective implementation of STEM-oriented approach in education.**

For the effective implementation of a STEM-oriented approach in education, it is important to use educational e-platforms that satisfy the interests of students in STEM fields, influence the development of research students' creative skills and abilities; help the teacher to solve the problems of motivation of students of higher education during their studies, to create in the educational environment educational projects, creative tasks, problematic issues that will contribute to the quick and high-quality application of skills and abilities by students from all STEM educational disciplines with the help of knowledge synergy.

To support the STEM-oriented environment of higher education, the educational e-platform provides:

– means (ICT) that ensures cooperation and communication between students; between teachers; between students and teachers; employers, specialists, students, teachers, etc., which can be carried out with the help of Internet conferences, webinars, open forums, etc.;
– open electronic educational resources, which include resources for teachers and students of higher education and through electronic libraries, electronic textbooks, blogs of scientific and pedagogical workers and students, distance courses, websites of the Ministries of Education, etc. may be distributed;
– online self-assessment and evaluation, which is carried out through Olympiads, contests, quests, projects, tests, etc., which contribute to the development of information and digital competence and future specialists, motivate students to study the STEM discipline and, by the requirements of society, contribute to the modernization of education;
– individual profiles of members of the educational, STEM-oriented environment, where data about the participant, participation in STEM projects, student academic achievements, and certificates can be placed; forums where the student of higher education participates and other electronic educational resources that are necessary for teaching or learning;
– innovative laboratories covering simulation models, games, stimulators, etc. (Soroko, 2019).

Most often, gifted youth join STEM, who strive for the further application of new knowledge obtained by innovative methods, and are interested in STEM education from the point of view of using modern equipment:

– 3D printers,
– holographic means,
– educational electronics, etc.

With its help, students of higher education learn in practice how to create a certain product, design, and analyze their own actions during the performance of a certain task.

**Approaches to the organization of STEM education.**

Let's highlight the most important approaches that are used for the organization of STEM education:

– within the study of certain educational subjects – organization of problem-oriented activities;
– for the further choice of the direction of scientific or technical activity, better understanding of the material – integration of knowledge of STEM subjects;

– using the method of projects, technological education, problem-oriented learning – practical orientation of STEM subjects;
– for full implementation of the STEM approach – integration of several subjects into one curriculum (Borzyk et al., 2023).

When implementing and creating STEM projects in institutions of higher education, it is important and necessary to use information and communication technologies, and virtual and augmented reality technologies (Soroko, 2021). The teaching of theoretical material in institutions of higher education is implemented with the help of video broadcasts, presentations, placement of text materials, etc., and the organization of scientific school excursions, laboratories, practical classes, etc., which require a special approach and require the mandatory use of virtual and augmented means, becomes a significant problem. Reality.

When creating a STEM project, the teacher must determine the problematic issue that will be solved by students of higher education, develop additional questions for planning activities, clarify research methods, and research hypotheses, selecting virtual and augmented reality tools for work on the STEM project and creating their products, such as research presentations using DR applications (Acrossair, Layar, Wikitude, Vuforia, Aurasma, Metaverse, Blippar, UniteAR, etc.), or stories or a virtual museum using Web platforms (Blippar, CoSpaces, Metaverse, etc.), which opens up new possibilities in the organization of the educational process. These tools, as a supplement to the organization of STEM projects, can be used to motivate students to study STEM subjects. Their expediency is necessary when studying the most complex topics and for training professional skills, which will significantly improve students' perception of the material, and the educational process, and expand the opportunities for them to carry out laboratory work and research (Gayevska & Soroko, 2022).

**Experiment**

The purpose of the experimental work was to reveal the importance and the necessity of organizing a STEM-oriented environment in institutions of higher education and clarify the ways of using STEM technologies in higher education with a view to the formation of professional skills.

We developed an anonymous questionnaire that was used to understand the importance of organizing a STEM-oriented environment in institutions of higher education and to find out ways of using STEM technologies in higher education with a view to the formation of professional skills.

The questionnaire contained closed-type and open-type questions.

Based on the analysis of the survey results, we asked the question and found out: "Which specific style of communication should dominate the implementation of "STEM technologies?". The respondents believe that a certain style of communication should dominate the communication between students of higher education and teachers to establish an effective educational interaction for the implementation of "STEM technologies":

– liberal (6.0%).
– democratic (46.5%);
– humanistic (47.5%).

As a result of the experimental work, we found out that from all (145) respondents – 30% use STEM technologies in higher education to form professional skills.

Answering the question: "What is most important to you in the process of using STEM technologies?" respondents singled out:

– creation of problem situations – 94% (STEM, according to the respondents, provides an opportunity through projects and practical tasks to develop problem-solving skills, promotes critical thinking and a creative approach;
– changing the role of the teacher – 92% (from the contributor, the use of STEM approaches requires a transition to the facilitator of learning. – from the role of "narrator");
– integration of subjects – 98% (STEM supports the integration of subjects, which is important for building connections between different areas of knowledge – respondents believe, and also contributes to a deep understanding of concepts and assimilation of material);
– use of digital technologies and tools – 87% (a key aspect of STEM approaches is the use of modern technologies to increase interest and effectiveness of education);
– development of creativity – 93% (STEM supports students' development of creative skills, and stimulates innovativeness and creative thinking).

***Table 1.***
*The use of STEM technology in higher education for the formation of professional skills*

| What is most important to you in the process of using STEM technologies? | Answers in % |
|---|---|
| Creation of problem situations | 94 |
| Changing the role of the teacher | 92 |
| Integration of subjects | 98 |
| Use of digital technologies and tools | 87 |
| Development of creativity | 93 |

The respondents gave the following answers to the question "What difficulties may students of higher education encounter when using the STEM approach in higher education classes?"

- technical training – 92% – experience difficulties in implementing digital technologies, developing projects related to science or engineering that require specific technical skills;
- integration of subjects – 54% – requires additional resources and additional time for the development of projects and integrated lessons;
- lack of time – 47% – for opportunities to work in groups, for creative activities, classes;
- lack of access to resources – 41% – there is a lack of equipment, necessary materials, and technical means for conducting STEAM projects;
- monitoring of integrated projects – 39% – efficiency of ensuring a balance between the development of practical and creative skills and the assessment of subject knowledge.

**Table 2.**
*The use of STEM technology in higher education for the formation of professional skills*

| What difficulties may students of higher education encounter when using the STEM approach in higher education classes? | Answers in % |
|---|---|
| Technical training | 92 |
| Integration of subjects | 54 |
| Lack of time | 47 |
| Lack of access to resources | 41 |
| Monitoring of integrated projects | 39 |

Introducing a STEM approach to education, despite the aforementioned difficulties, can lead to a fruitful and stimulating learning environment.

Therefore, the analysis of questionnaire data on the use of STEM technologies in higher education shows that in institutions of higher education that successfully integrate this approach, students achieve significant results in development and learning.

A key aspect of the STEM approach is a creative approach to teaching, creating a stimulating environment where students can develop critical thinking and apply their creativity.

Our method of studying educational technologies was to use the method of surveying teachers and students who implement forms of STEM education and various directions in education. The research was conducted online. Quantitative and qualitative analysis procedures were used to process empirical data.

For comparative analysis and generalization of data, to ensure the possibility of comparison of data, they are given in relative values (%).

The majority of respondents use the following technologies (as data analysis showed): as an organization of educational group activities, project activities, and formation of a creative personality. Cooperative learning is more interesting and effective. This is what the respondents said. They noted the importance of a benevolent attitude towards each student of higher education, joint creative activity, and willingness to help, which contributes to their moral development and intellectual development. Joint creative activity promotes the use of project technology. Modern educational technologies show the importance of the leading principle of STEM education – transdisciplinary integration.

**Guidelines.**

Methodological recommendations have been developed for the implementation of the STEM approach in the practice of the educational process, where it is necessary to organize a STEM-oriented environment in higher education institutions and create certain optimal conditions, namely:

- use of group work, design, and scientific, interactive, teaching methods to create an atmosphere of co-creation, cooperation, and self-realization of each individual.
- creation of a society for interpersonal tolerant democratic interaction, to promote a dialogical and humanistic style of communication;
- application of problematic actual situations for the productive, creative activity of higher education students.

To best prepare a student for the use of STEM in professional activities, the following algorithm of actions should be followed:

1) introduction to the concept of STEM (declaration of the main values and principles of the STEM approach. Explanation of how science, engineering, technology, mathematics, and art can be integrated to improve educational activities and the development of students.
2) conducting experiments, considering the possibility of using technologies, solving real problems;
3) project development: designing projects that combine science, engineering, technology, mathematics, and art with other STEM fields;
4) acquaintance with digital tools for the development of the student's technological skills, to use them to support STEM approaches (virtual reality, modeling, etc. technologies);
5) to develop joint projects – cooperation with teachers of other subjects to enrich the experience of students;
6) formation of a stimulating and creative environment in the educational space, providing access to various tools and materials that contribute to the creativity of the individual;
7) involvement of technical experts in the institute to establish connections with specialists in the fields of technology, science, and engineering for the opportunity to see how STEM is used in real life;
8) evaluation of the process, not only the results of activities, the development of an evaluation system that takes into account cooperation, the work process itself, a creative approach, and not only the final results of projects.

The practical significance of the research lies in the development and implementation in the practice of higher education institutions of the methodology of applying STEM technologies in the process of training future specialists and providing a scientific and methodological basis for this process: lectures, practical classes, laboratory research, which will contribute to the improvement of the quality of education and the readiness of graduates for challenges of the modern labor market, as well as in the improvement of pedagogical practice.

Theoretical provisions for improving the content, forms, methods, and conditions of professional training of future specialists for the use of STEM technologies in the higher education system have gained further development.

In our opinion, the priorities in the professional training of future specialists for the use of STEM technologies in the higher education system should be the wide use of computer-oriented tools and ICT training in the educational process, the introduction of distance learning technologies, the provision of support for research work with the help of ICT, implementation of ICT in education management at various levels, in various fields, for all types of educational institutions.

The technological principles of building such an environment should be, first of all, the use of cloud computing technologies, taking into account the developers of web applications and electronic educational resources, the features of various computer and technological platforms, effective mechanisms for the use of ICT outsourcing, requirements for educational and training environments with on the part of the state, the Ministry of Education and Science, subjects of the educational process.

Strengthening of information and communication support, informational and informatics training of pupils, students and teachers should be central to the content of education; introduction of ICT in teaching and learning of all disciplines of educational institutions. To create a wide range and pedagogically balanced use of software tools

for various purposes, in particular educational and managerial, which takes into account the psychological and pedagogical aspects of building methodical systems of learning and an open computer-oriented learning environment and provides for the mandatory involvement of scientists, teachers in the creation of electronic resources, innovative teachers of educational institutions.

The specific weight of educational materials in electronic form should constantly increase.

**Conclusions**

The content of the concept of STEM education is analyzed, and personal and social aspects are revealed. The main organizational forms and open online tools for the implementation of STEM education are shown. The most important functions and goals of the educational environment provided by Google services for the implementation and organization of STEM projects in higher education institutions are highlighted. the importance of a STEM-oriented approach in education is emphasized.

It has been found that for the process of higher education to correspond to the STEM concept, it is necessary to turn training towards the teamwork of the higher education students themselves, to change the usual form of teaching when the class takes place around the teacher of a higher school.

It has been proven that the method of teaching STEM education is based on the organization of creative experimental activities and practical activities. Such forms of organization of learning as learning through deliberate play, teaching by topics through innovative approaches, simulation of real experience, and clubs allow students to explore, ask questions, and solve problems. The more complex the games, which require more skills (problem-solving, social communication, etc.), the better the higher education students will be able to learn the new material.

For the effective implementation of a STEM-oriented approach in education, it is emphasized the mandatory use of educational e-platforms that satisfy the interests of students in STEM fields, influence the development of research students' creative skills and abilities; help the teacher to solve problems of motivation of students of higher education during their studies, to create in the educational environment educational projects, creative tasks, problematic issues that will contribute to the quick and high-quality application of skills and abilities by students from all STEM educational disciplines with the help of knowledge synergy.

The most essential approaches used for the organization of STEM education are highlighted.

When implementing and creating STEM projects in institutions of higher education, it is important and necessary to use information and communication technologies, and virtual and augmented reality technologies.

The teaching of theoretical material in institutions of higher education is implemented with the help of video broadcasts, presentations, placement of text materials, etc., and the organization of scientific school excursions, laboratories, practical classes, etc., which require a special approach and require the mandatory use of virtual and augmented means, becomes a significant problem. Reality.

Introducing a STEM approach to education, despite the aforementioned difficulties, can lead to a fruitful and stimulating learning environment.

A key aspect of the STEM approach is a creative approach to teaching, creating a stimulating environment where students can develop critical thinking and apply their creativity.

Through experimental research, the importance and necessity of organizing a STEM-oriented environment in institutions of higher education was revealed, and the ways of using STEM technologies in higher education with a view to the formation of professional skills were clarified.

Methodological recommendations have been developed for the implementation of the STEM approach in the practice of the educational process, where it is necessary to organize a STEM-oriented environment in higher education institutions and create certain optimal conditions.

Disclosure of ways to provide Google services for the implementation and organization of STEM projects in higher education institutions requires further research.

**Bibliographic References**


Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology, 53*(11), 2919-2955. https://doi.org/10.1080/0020739X.2021.1922943

Borzyk, O., Moskalyuk, O., Yemets, Z., Vysochan, L., & Yashchuk, O. (2023). STEM as an innovative strategy of integrated education: World experience and development prospects. *Herald of Science and Education, 1*(7), 383-396. https://doi.org/10.52058/2786-6165-2023-1(7)-383-396

Costley, J., & Lange, C. (2017). The Mediating Effects of Germane Cognitive Load on the Relationship Between Instructional Design and Students' Future Behavioral Intention. *The Electronic Journal of e-Learning, 15*(2), 174-187. https://files.eric.ed.gov/fulltext/EJ1141882.pdf

Etherington, D. (2014). *Google debuts Classroom, an education platform for teacher-student communication*. Tech Crunch. Retrieved from https://acortar.link/HcoZrA

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education, 7*(24). https://doi.org/10.1186/s40594-020-00225-4

Gayevska, O., & Soroko, N. (2022). The pedagogical strategies with immersive technologies for teaching and learning the Japanese language. *Information Technologies and Learning Tools, 92*(6), 99-110. https://doi.org/10.33407/itlt.v92i6.5133

Kryvoruchko, I., & Shukatka, O. (2023). Features of implementation of STEAM education in Ukraine and Latvia (pp. 91–93). In *Actual aspects of the development of STEAM education in the conditions of European integration: A collection of materials of the International Scientific and Practical Internet Conference*. Kropyvnytskyi: DonDUVS. https://acortar.link/QchKqz

Kryvovyaz, A., Slyvka, M., Korol, N., Kut, M., & Onysko, M. (2023). Prospects of using elements of STEAM education in chemistry lessons (pp. 89–90). In *Actual aspects of the development of STEAM education in the conditions of European integration: A collection of materials of the International Scientific and Practical Internet Conference*. Kropyvnytskyi: DonDUVS. https://acortar.link/QchKqz

Liao, C. (2019). Creating a STEAM map: A content analysis of visual art practices in STEAM education. *In STEAM Education: Theory and Practice* (pp. 37–55). Springer. https://doi.org/10.1007/978-3-030-04003-1_3

Magid, L. (2014). *Google Classroom offers an assignment center for students and teachers*. Forbes. https://acortar.link/gm3KvL

Mell, P., & Grance, T. (2011). *The NIST Definition of Cloud Computing*. NIST Special Publication. https://doi.org/10.6028/NIST.SP.800-145

Polihun, N. I., Postova, K. H., Slipukhina, I. A., Onopchenko, H. V., & Onopchenko, O. V. (2019). *Implementation of STEM education in conditions of integration of formal and informal education of gifted students: Methodological recommendations*. Kyiv: Institute of the Gifted Child of the National Academy of Sciences of Ukraine. https://core.ac.uk/download/pdf/286032301.pdf

Rudenko, N., & Zaitseva, S. (2022). Implementation of elements of STEAM education in foreign language classes in the conditions of online learning. *Current Issues of Humanitarian Sciences, 57*(2), 277-284. https://doi.org/10.24919/2308-4863/57-2-43

Sharova, T., Sharov, S., & Kreminskyi, B. (2023). Educational resources for the organization of STEAM education. *Youth and the Market, 3*(211), 52-56. http://www.tsatu.edu.ua/kn/wp-content/uploads/sites/16/stranycy-yz-16563-9071-pb.pdf

Shernof, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education, 4*(13), 1-16. https://doi.org/10.1186/s40594-017-0068-1

Soroko, N. V. (2019). Use of educational electronic platforms for organizing STEAM-oriented educational environment of elementary school (foreign experience). *Scientific Notes Series: Pedagogical Sciences, 183*, 155-158. https://doi.org/10.36550/2415-7988-2019-1-183-155-158

Soroko, N. V., & Pylypchuk, I. L. (2020). Organization of a STEAM-oriented educational environment of a general education institution with the help of Google services. *Proceedings. Series: Pedagogical Sciences, (191)*, 161-164. https://doi.org/10.36550/2415-7988-2020-1-191-161-164

Soroko, N. V. (2021). The augmented reality functions to support STEAM education at general education institutions. *Physical and Mathematical Education, 3*(29), 24-30. https://doi.org/10.31110/2413-1571-2021-029-3-004

Yakman, G. (2017). STEAM Education Professional Development Practicum & Research 2007-2017. *Proceedings of the PATT*, 34. https://acortar.link/jKiVtf

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education, 16*(39). https://doi.org/10.1186/s41239-019-0171-0

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