2.1. Implementation of the STEAM Approach in a Technical University Through Humanities Courses and Interactive Learning

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***Abstract**. The issue of the STEAM approach and its effectiveness in the training of future specialists in technical fields (engineers) remains quite controversial today. Therefore, this study proposes an authorial vision for integrating the STEAM approach into the educational process and outlines prospects for its development in a technical university through humanities courses. The subsection "Step by Step: Transforming Technical Education through STEAM Approaches" presents the theoretical foundations of STEM and STEAM education, drawing on the experiences of foreign and Ukrainian scholars. A set of functions that the STEAM approach performs in the educational process is defined. The subsection "Formation of Engineering Competencies in the STEAM Space: Methods and Technologies" analyzes teaching methods and technologies, their classification, and the experience of implementing optimal strategies for realizing the STEAM approach by both international and domestic educators. The third subsection, "Methodology of Integrating the STEAM Approach into the Teaching of Humanities in Technical Universities," describes the methodology of conducting classes in the course "Psychology of Personality" based on the STEAM approach, using interactive (active) teaching methods and technologies, as well as the specifics of their assessment. The paper also presents prospects for further implementation of the STEAM approach through the author's developed course "Cultural Studies of Mathematics." The conclusions highlight the problems encountered during the implementation of the STEAM approach through the lens of humanities education and the use of interactive (active) educational technologies in the formation of future specialists in technical fields.*

***Keywords**: STEAM approach, interactive (active) educational technologies, future specialists in technical fields, humanities disciplines.*

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Introduction

In the context of social transformations and global challenges of the 21st century, technical higher education faces issues not only in the domain of professional training but also in developing innovative, creative, value-oriented, and critical thinking among future engineers. Society continues to seek optimal educational forms of integration and interdisciplinarity to help students better understand their future profession at both theoretical and practical levels, as well as on cultural and spiritual levels. The STEM education model (Science, Technology, Engineering, Mathematics) remains both relevant and valuable, as it emphasizes the natural sciences, engineering, technology, and mathematics, proving its effectiveness in fostering scientific and technological progress.

Both international and Ukrainian scholars have contributed to the study of implementing the STEM model in education. Among foreign researchers are M. Wolfmeyer, T. Kelly, D. Clements, J. Lupinacci, J. Maeda, J. Knowles, J. Sarama, and N. Chesky. In Ukrainian pedagogy, the topic has been addressed by V. Boichenko, N. Honcharova, L. Hrynevych, A. Kokarieva, O. Liashenko, V. Miziuk, N. Morze, I. Slipukhina, O. Stryzhak, A. Ovchatova, H. Onopchenko, O. Onopchenko, N. Polikhun, K. Postova, and others.

Despite the extensive research on implementing STEM in educational processes, current pedagogical paradigms are increasingly emphasizing art, culture, creativity, and the humanization of technical education. The problem, nevertheless, is not limited to developing creativity among future engineers. It also concerns professionals in other fields, since the absence of a connection between engineering and cultural foundations can threaten the very essence of engineering thinking, leading to the dehumanization of technological inventions. This destructive tendency is already visible: many technological achievements that could serve humanity, such as drones, are used in warfare rather than agriculture, mining, or other peaceful industries.

Therefore, it is essential to preserve humanity, morality, national identity, and cultural distinctiveness among future engineers through higher education institutions. These institutions should serve not only as centers of knowledge but also as spaces of culture and spirituality, shaping a new elite capable of advancing both technological and cultural progress, while learning to integrate humanitarian aspects into professional knowledge, skills, and practices. For this reason, we consider it necessary to extend the STEM model by adding creative foundations, thus implementing the STEAM approach in the educational process of technical universities.

Global socio-economic realities, multicultural dynamics, and military conflicts are reshaping how STEAM approaches are perceived, emphasizing the interconnection between technology and culture. Over recent decades, various transformations of STEM have been explored: STEAM (STEM + Arts), STEMM (STEM + Medicine), and STREAM (STEM + Reading/Writing + Arts). Today, we believe the integration of STEAM (STEM + Arts) into engineering education is particularly relevant, alongside the search for optimal teaching methods and technologies to ensure its effective implementation.

The implementation and methodological development of the STEAM approach in training students have been examined by numerous researchers worldwide, including S.-Y. Byun, J. Katz-Buonincontro, D. Clements, J. Maeda, J. Michael, J. Sarama, H. Park, E. Perignat, M. Schlesinger, and J. Yakman. In Ukrainian pedagogy, this issue has been addressed by A. Brovchenko, O. Isaieva, V. Tymenko, S. Poida, H. Shainer, O. Yatsyna, and others.

The STEAM approach to training future specialists requires a rethinking of traditional pedagogical strategies in technical higher education. There is an increasing demand for effective teaching forms and methods that can meet the professional needs and competencies of future engineers. Whether innovation is indispensable or traditional approaches can be transformed to achieve similar outcomes remains an open question. Rapid technological progress often outpaces the educational system's ability to implement new methods, rendering many innovations short-lived, particularly in the training of engineers.

This study offers an authorial perspective on selected aspects of integrating the STEAM approach into the training of future engineers.

Step by Step: Transforming Technical Education through STEAM Approaches

The technologization of society has contributed to the improvement of educational paradigms, making STEM approaches increasingly popular. Initially, STEM was designed to harmonize theory and practice. Scholars emphasize that such approaches in education are crucial for maintaining sustained interest in research, encouraging professional mastery, and developing creativity and independence (Ovchatova, 2021). They also enhance motivation for studying science and mathematics, as well as for mastering the fundamental competencies required to solve problems in fields such as engineering, medicine, ecology, and information technology (Chornomorets & Vasylenko, 2023).

There are currently different perspectives on defining STEM education. Some researchers describe it as "a pedagogical approach that integrates diverse directions" (Buriak, 2018); others as a synthesis of science and art that fosters creativity (Kolomiiets, 2017); or as a modern tool for developing a learner's creative abilities, where the process begins with play and gradually leads to the acquisition of new knowledge and practical skills (Shulykin, 2015). In the context of technical higher education, STEM is perceived as "a contemporary educational phenomenon that enhances students' understanding of disciplines... aiming to prepare them for the effective application of acquired knowledge to professional challenges, particularly through improving higher-order thinking skills and developing competencies" (Podliesnyi & Tarasov, 2019). Another definition views it as "an approach based on the principles of interdisciplinarity, the integration of theoretical and applied components, the digitalization of educational content, and the development of soft skills among future specialists in technical fields" (Kravchenko et al., 2025).

Foreign scholar M. Wolfmeyer emphasized that, in its early stages, the STEM movement served its initial purpose of ensuring economic and military competitiveness (Wolfmeyer, 2015).

A group of international researchers later applied Karen Barad's concept of agential realism to describe the ontological dimensions of STEM education. Agential realism combines epistemology and ontology, positing that reality does not exist independently of the observer but is formed through interaction between the observer and the observed object. The authors identified three overlapping dimensions of this ontology: STEM as an apolitical educational trend, STEM as a Eurocentric economic policy, and STEM as a discursive episteme (Wolfmeyer, Lupinacci, & Chesky, 2017). This framework allows STEM to be perceived in multiple dimensions, revealing its systemic complexity. Such an approach is particularly valuable when discussing the development of competencies among future engineering professionals whose education is grounded in STEM principles yet requires conceptual expansion toward broader horizons.

In Ukraine, the development of STEM education began in 2015, when the Ministry of Education and Science of Ukraine hosted a roundtable discussion on the prospects of STEM education and its implementation in the national educational system. A series of measures were approved for 2016-2018, including four priority areas: legal and regulatory support; improvement of normative documents; development of regulations on STEM education and integrated curricula for special courses and electives; creation of methodological resources for various types and levels of educational institutions; and organization of academic events such as conferences, seminars, symposia, webinars, and competitions. A milestone in this development was the adoption of the Concept for the Development of Natural and Mathematical (STEM) Education, followed by the issuance of the Ministry's Order "On the Establishment of a Working Group on the Implementation of STEM Education in Ukraine" (2016).

Currently, Ukraine actively implements STEM education through specialized centers and laboratories, which provide the conditions for experimental work and enable students of all ages to engage in STEM-based studies.

Thus, when considering the implementation of STEM in the educational process, it can be stated that this approach represents a system of knowledge capable of combining and integrating different domains into a coherent professional direction. Moreover, when necessary or as needed, it can remain flexible and responsive to social, scientific, and educational changes.

Increasingly, certain factors demand a new perspective on how STEM is implemented in technical education (specifically within Ukrainian higher technical institutions). These factors have contributed to the expansion and humanization of the concept. One such factor is the development of professionally essential skills, which in psychological and pedagogical literature are commonly divided into soft and technical skills. Soft skills are mostly associated with psychological and personal characteristics, while technical skills relate to cognitive and technical abilities.

International researchers classify soft skills as non-technical, intangible, and personal abilities that encompass qualities such as leadership and conflict mediation attributes not rooted in technical expertise (Ballarm, 2015). Other scholars emphasize the significance of soft skills in enhancing communication, interpersonal relationships, management efficiency, and ethical or moral decision-making, including persistence, problem-solving, teamwork, self-discipline, and time management (Robert W. Gaines & Mecca B. Mohamed, 2014).

As previously discussed in our study on developing soft skills among future specialists in technical fields (Hrechanovska, 2024), contemporary Ukrainian education is structured around competencies outlined in the educational and professional programs of technical universities. Among these competencies are:

– the ability to think abstractly, analyze, and synthesize;
– project development and management skills;
– teamwork and cross-cultural collaboration;
– environmental responsibility;
– clear and unambiguous communication of professional knowledge and arguments to both experts and non-specialists, including students;
– proficiency in information and communication technologies;
– lifelong learning and continuous professional development;

– adaptability and readiness to act in new situations;
– creativity and idea generation;
– problem identification and problem-solving;
– the ability to communicate effectively with representatives of various professional groups and industries;
– independence and leadership within group settings;
– analytical reasoning and synthesis of complex information.

Analyzing these professionally significant competencies and personal traits of future engineers reveals that they cannot be formed solely through technical knowledge, skills, or abilities. They constitute the foundation of engineering practice, which must be integrated with cultural, social, and humanitarian disciplines such as cultural studies, psychology, ethnopsychology, and pedagogy. Consequently, STEM should be viewed as a process requiring transformation, expansion, and integration with artistic and humanistic dimensions principles at the core of STEAM education.

Nevertheless, some international scholars argue that expanding STEM in this direction may weaken its technical focus and dilute its original intent (Clements & Sarama, 2021). This makes the introduction of STEAM into higher education both complex and debatable. Nevertheless, we concur with E. Perignat and J. Katz-Buonincontro, who view STEM and STEAM as interdependent educational constructs, each having emerged in response to the other (Perignat & Katz-Buonincontro, 2019).

The position of researcher Georgette Yakman, an engineering and technology educator with a master's degree in education, is particularly noteworthy. Yakman is recognized as the founder of the STEAM educational framework, which she developed in 2006, with its implementation beginning in 2007. Her approach is compelling because she did not seek to reinvent or replace the existing STEM structure but rather to systematize and enrich it. Her studies demonstrated how the inclusion of the humanities provides a contextual dimension to STEM education. Yakman emphasizes that STEAM is "more than the combination of fine arts with STEM, as the humanities add the questions of 'who' and 'why' to the 'what' and 'how' of STEM" (Yakman, 2019).

This approach humanizes STEM by shifting it toward cultural and ethical awareness, fostering creativity, and promoting a more holistic understanding of technological education. It also expands the methodological possibilities of teaching, enhances interdisciplinary connections, and supports the development of learner-centered education.

Some foreign scholars argue that the relationship between STEM and STEAM is natural and evolutionary, with one emerging as a response to the appearance or development of the other (Perignat & Katz-Buonincontro, 2019).

An insightful contribution to the conceptualization of STEAM was made by Jefferson Rodrigues-Silva and Ángel Alsina in their analytical and methodological study "Conceptualising and Framing STEAM Education: What Is (and What Is Not) This Educational Approach?" The authors focus on the history, epistemology, and differences between STEM and STEAM, proposing an analytical framework that clarifies what STEAM is not. Their position, which we share, is that STEAM does not pose a threat to STEM education nor diminish the value of technical disciplines.

According to their findings, STEAM is not:

– An evolution of STEM, since it emerged from a creative and philosophical tension rather than as a linear progression;
– A single teaching methodology, because it employs multiple methodological approaches and builds upon them instead of replacing them. STEAM may rely on one methodology, while others enhance its interdisciplinarity (Jefferson Rodrigues-Silva & Ángel Alsina, 2023);
– A synonym for interdisciplinarity, as "interdisciplinarity refers to dialogue among disciplines in general, whereas STEAM represents such dialogue within a specific cluster of disciplines defined by the acronym, aiming to modernize curricula" (Moore et al., 2014);
– An attempt to erase disciplinary boundaries through transdisciplinarity. On the contrary, this educational approach is firmly grounded in the disciplines that constitute it (Jefferson Rodrigues-Silva & Ángel Alsina, 2023).

The researchers identify two essential conditions for STEAM education: interdisciplinarity and inclusion of the core disciplinary domains represented in the acronym. They emphasize that the term STEAM disciplines explicitly refers to the set of knowledge areas encompassed by Science, Technology, Engineering, Arts, and Mathematics.

Rodrigues-Silva and Alsina also draw a distinction between STEAM education and STEAM activity. They define STEAM education as “an educational approach that promotes interdisciplinary teaching of STEAM disciplines through their respective sets of practices,” while a STEAM activity or lesson is “a practical form of interdisciplinary teaching that integrates at least two STEAM disciplines” (Jefferson Rodrigues-Silva & Ángel Alsina, 2023).

In Ukrainian pedagogy, a number of scholars do not emphasize a strict distinction between STEM and STEAM, viewing them instead as educational approaches that function as “an integrative pedagogical technology based on the combination of content from the natural sciences, technology, engineering, mathematics, as well as the arts and socio-humanitarian disciplines for organizing the educational process” (Polikhun et al., 2023). Ukrainian researchers also argue that meaningful progress in education can be achieved only through the integration of the arts with the natural sciences, technology, engineering, and mathematics. The implementation of the STEAM approach, therefore, enriches and elevates STEM education to a new level, preparing modern students for innovative and productive professional activity (Kuzmenko, 2020).

In higher education pedagogy, scholars investigating STEAM education view it as a priority over traditional instruction, emphasizing that such an approach prepares graduates to be competitive in the labor market. According to Isaieva (2022), “STEAM education focuses on solving real-life problems or performing practical tasks, which ensures the acquisition of skills for the practical application of knowledge.”

Ukrainian scholars generally conceptualize STEAM education as a comprehensive educational approach that integrates the disciplines represented in the acronym to foster well-rounded, creative, analytical, and practical abilities in students. According to Bocharova and Dorosh (2023), this methodology aims to prepare students for problem-solving through interdisciplinary learning that encourages innovative and critical thinking, teamwork, and adaptability.

Bocharova and Kudriavtseva (2024) identify several core goals and advantages of STEAM education:

– Critical thinking development – analyzing information, applying scientific methods, and engineering design to solve problems;

– Creativity and innovation – integrating the arts to foster creative thinking and innovative decision-making;

– Interdisciplinary learning – connecting various disciplines to help students see the relationships among different fields and apply integrated knowledge in real-world contexts;

– Practical application – employing project-based learning and hands-on activities;

– Future readiness – developing flexibility and adaptability for work in rapidly changing technological environments.

Having analyzed the scientific literature on the integration of STEAM into higher education, we conclude that the issue remains insufficiently explored, particularly in the context of technical universities and the professional training of engineers. We concur with several international scholars who argue that STEAM is not an evolution of STEM, nor a methodology, nor a synonym for interdisciplinarity (Jefferson Rodrigues-Silva & Ángel Alsina, 2023; Moore et al., 2014). These conceptual ambiguities make the implementation of STEAM in technical universities a challenging endeavor.

Discussions about STEAM are often approached cautiously and do not fully reveal the depth and potential of this approach. Most attention is given to STEAM in institutions that focus on the arts or related disciplines, whereas technical universities tend to implement it more conservatively, emphasizing the technological aspects while underestimating the equal importance of the sciences and arts within the model.

In our view, the balanced interaction among all STEAM disciplines is crucial. Such an equilibrium enables students to understand how different domains interact and how the STEAM framework contributes to the development of essential competencies. This approach ensures the integrative nature of learning, where each discipline is revealed through the lens of practical application, creative thinking, and interdisciplinary collaboration. Nevertheless, the inclusion of the arts component in STEAM, while valuable, should be considered with caution: its application in technical higher education may not always be pedagogically justified or contextually relevant.

Researchers identify several key objectives of STEAM education in technical universities, which include (Isaieva, 2022): the development of competencies demanded by the labor market; readiness to address complex and multifaceted challenges that often involve contradictory situations; the ability to accurately assess problems and make timely decisions; effective interpersonal interaction through empathy toward the end-user or team members; communication skills across diverse age groups; the creation of a positive and collaborative atmosphere characterized by patience and respect; conflict resolution skills; and cognitive flexibility mental agility that enables rapid shifts in reasoning and the capacity to examine a problem or object from multiple perspectives simultaneously.

Additionally, STEAM education aims to foster the comprehensive development of the individual, shape value orientations, meet students' needs and interests, and cultivate a holistic scientific worldview along with scientific, technological, cultural, ecological, communicative, and social competence through knowledge acquisition. It aims to develop a morally responsible personality capable of making independent and ethical choices, fostering lifelong learning, promoting respect for work, and supporting personal and professional self-determination (Isaieva, 2022).

Within the educational process, the STEAM approach performs several interrelated functions, among which the following are particularly significant:

Motivational function. It stimulates students' interest in acquiring knowledge that may not directly relate to their specialization, but, when applied, enriches professional understanding through practical, creative, interactive, and project-based tasks.

Integrative function. It combines various fields of knowledge into a unified educational context, fostering interdisciplinary thinking and helping students connect theoretical and applied dimensions across disciplines.

Competence-based function. It supports the development of key and professional competencies, as well as future skills, engineering thinking, creativity, critical and analytical reasoning, communication, and collaboration.

Innovative technological function. It serves as a driver of educational transformation, uniting engineering and artistic thinking, introducing innovative teaching methods and technologies, and promoting technological creativity, adaptability to digital changes, and flexibility in professional knowledge.

Practice-oriented function. It bridges theory and practice through interactive and project-based learning, enabling students to solve real-world problems and create modern technical or artistic products.

Cultural integrative function. It harmonizes technical and humanitarian components of education by linking artistic, cultural, and technical thinking. This function enhances aesthetic awareness, intercultural tolerance, and emotional intelligence, fostering the ability to understand the cultural dimension of technical activity and to design products that are not only functional but also socially meaningful and culturally grounded.

Thus, the implementation of the STEAM approach in technical universities creates opportunities to rethink traditional teaching methods and technologies, to redesign learning content in line with modern challenges, and to cultivate in students a holistic understanding of intersectoral connections that link science, technology, engineering, the arts, and mathematics into a coherent and human-centered educational paradigm.

Formation of Engineering Competencies in the STEAM Space: Methods and Technologies

Today, the STEAM approach is positioned as an innovative educational paradigm that integrates scientific, technical, engineering, cultural-artistic, and mathematical components to create a holistic learning environment. STEAM-oriented education focuses on practice-based, project-based, problem-oriented, and learner-centered learning, activating not only cognitive processes but also influencing the emotional and value dimensions of the individual. It fosters teamwork, decision-making in non-standard situations, and the ability to design one's own educational trajectory.

When addressing the training of future specialists in technical fields, researchers emphasize that STEAM education is an essential component of engineering preparation. Therefore, creative thinking should be nurtured from school through diverse activities involving information and communication technologies, research-based learning, and project work (Hrybiuk, 2015).

The choice of teaching methods and technologies in higher education remains a key issue across disciplines, and various classifications and interpretations exist in pedagogical literature. Therefore, it is crucial to determine which are most effective for implementing the STEAM approach in training future engineers.

To clarify this, it is necessary to distinguish between learning methods and technologies. The term "method," derived from the Greek, literally means "path" or "way." In education, it denotes a path toward achieving a goal, a way of organizing and directing activity. Accordingly, a teaching method is understood as an organized form of interaction between the teacher and the student, aimed at achieving educational objectives (Aleksiuk, 1981). Bartmańska (2006) describes it as a means of achieving a goal, a planned course of instruction that defines the strategy of the teacher's pedagogical activity.

In Ukrainian pedagogy, methods of learning are viewed as a binary system of techniques, tools, and sequential actions performed by both the teacher and the learner to acquire knowledge, skills, and competencies, as well as to achieve educational and developmental goals (Honcharenko, 2003). Thus, methods can be considered components of a broader pedagogical technology.

Scholars analyzing the difference between technology and method emphasize two main characteristics of technology: orientation toward a specific result and the capacity to design the future learning process. Unlike methods, a technology is a structured, reproducible system; it is not inherently variable, although specific elements can be adapted or excluded (Pometun & Pyrozhenko, 2002).

In its original sense, the term technology was borrowed from the technical sciences, where it referred to a structured system of knowledge about organizing and executing production processes. Since the early 20th century, it has been adopted in pedagogy as the concept of "pedagogical technology," which came to mean an integrative process combining people, ideas, tools, and organizational strategies for analyzing problems of planning, implementation, evaluation, and management of all aspects of learning (Pometun & Pyrozhenko, 2004).

According to the Encyclopedia of Education (2008), pedagogical technology is understood as a means that transforms the educational process in an institution into a purposeful and organized activity involving all participants of the learning process.

In the context of the STEAM approach, this interpretation of pedagogical technology is particularly relevant, as it underscores the systemic, goal-oriented, and integrative nature of educational design qualities essential for forming the engineering competencies of modern students through interdisciplinary, creative, and practice-driven learning experiences.

A number of scholars argue that a learning technology is a "strictly algorithmized set of procedural and methodological actions performed by the teacher, along with the didactic tools used, which ensures effective learning activity of the student and the achievement of the projected outcome of the didactic cycle." Educational technologies, according to these authors, also include "methods and forms of organizing learning activity, means and tools of instruction, assessment and evaluation of knowledge acquisition, and procedures for correction and feedback."

Researchers emphasize that the essence of the term "learning technology" should rest upon a rigid algorithm of techniques, methods, and instructional strategies that guarantee the achievement of learning goals. They highlight the keywords algorithm, guarantee, and goal, insisting on a clear algorithmic sequence of actions and the assurance of a final result. This position aligns with our perspective, particularly in their interpretation of learning technology in a didactic context as a structured interaction between participants in the educational process.

Scholars have also proposed a structure of the technological learning process, comprising a hierarchy of interconnected stages: attention formation, motivation creation, goal presentation, activation (recall) of relevant prior knowledge, stimulation and guidance of learning activity, motivation of learning outcomes, verification of correctness of results, feedback through testing and necessary correction, and final criterion-based evaluation of outcomes (Lebedyk et al., 2020).

Undoubtedly, this structure can be effective; at the same time, as education involves human interaction, outcomes are not always predictable. Therefore, we believe that algorithms must remain flexible and adaptive in practice, especially within interdisciplinary frameworks such as those used in implementing the STEAM approach. The human factor introduces variability that necessitates pedagogical responsiveness and creativity rather than mechanical replication.

Ukrainian researchers identify educational technologies as one of the key tools used by teachers in their professional practice. They perform a special integrative function, serving as a pedagogical mechanism through which other instructional elements, such as communication, content, methods, techniques, and forms of organization, are applied and interconnected (Pometun, 2007). In this sense, technology influences all processes essential to knowledge acquisition and assessment, linking together the cognitive, emotional-value (affective), and physiological dimensions of the learner's experience.

We thus regard educational technologies as integrative systems that unite autonomous yet harmoniously functioning components, methods, forms, and instructional tools within the structure of a lesson. As for the purpose, objectives, and efficiency of using such technologies, we consider these aspects indispensable to any educational process, for without them, no meaningful pedagogical action can occur.

In modern pedagogy, numerous classifications of educational technologies have been proposed. One of the most detailed and systematized is that of I. Dychkivska (2001), who structured various types of instructional technologies. Building upon her typology, we analyzed these categories through the lens of STEAM integration into the preparation of future specialists in technical universities.

Structural-logical educational technologies involve goal setting, task formulation, methodological procedures, diagnostics, and assessment of learning outcomes. This resembles the algorithm proposed by Lebedyk et al. (2020), although we believe such structures must remain flexible and adaptable to transformation within STEAM-based education.

Integrative technologies encompass interdisciplinary and cross-subject integration, which lies at the heart of the STEAM paradigm.

Game-based technologies represent a crucial stage in STEAM implementation, as gamification enhances creativity, motivation, and emotional engagement.

Computer-based technologies serve as indispensable tools for conducting interdisciplinary activities, particularly in training the next generation of engineers. They promote understanding of the “human-technology” interaction and its social, ethical, and psychological implications.

Dialogic technologies focus on creating a communicative and cooperative learning environment, emphasizing subject–subject relations and collaboration among all participants of the educational process.

Instructional technologies encompass structured educational procedures and cognitive algorithms, such as testing, psychological and pedagogical training, and problem-solving sessions, designed to stimulate both intellectual and emotional engagement.

In her influential article "Teaching Methods for the 21st Century", J. Cox (2025) argues that traditional teaching approaches are no longer effective for contemporary students, as they fail to meet the cognitive and social demands of modern education. This discrepancy has led to the emergence of new teaching methodologies or innovative versions of older strategies. According to Cox, educators now employ advanced technologies to expand students' learning opportunities, and she highlights a range of innovative teaching approaches essential for contemporary teachers:

Active learning – engaging students through activities, group work, and discussions. This approach is student-centered, allowing students to participate in decision-making and thereby deepening their understanding and retention of the material.

Blended learning – a hybrid model combining traditional in-person teaching with technology-enhanced and online learning tools.

Inquiry-based learning, grounded in research practices, reverses the traditional "teacher explains–student listens" paradigm. Students formulate their own questions, cultivating curiosity, critical thinking, and research skills.

Cooperative learning – a student-oriented model based on teamwork, shared responsibility, and collective problem-solving. It develops independent thinking and collaboration skills.

Differentiated instruction – the use of multiple teaching methods to present the same content at varying levels of complexity, taking into account individual learner needs, styles, and abilities.

Culturally responsive teaching – aimed at establishing a shared understanding with students from diverse cultural backgrounds, fostering an inclusive learning environment that respects students' values and experiences.

Trauma-informed teaching – focuses on creating safe, supportive environments and acknowledges the impact of trauma on students' behavior and academic performance.

Social-emotional learning – prioritizes the development of emotional intelligence, empathy, and interpersonal communication skills.

Gamification – the integration of game mechanics into the learning process to enhance motivation, engagement, and creativity.

Flipped learning – a reversal of traditional instruction, where students acquire new knowledge outside the classroom (e.g., through digital materials) and apply it in class through discussion and problem-solving.

Project-based learning – emphasizes real-world problem-solving, critical thinking, collaboration, and communication, enabling students to apply knowledge in meaningful and practical contexts.

The approaches outlined by Cox (2025) align closely with the principles of STEAM education, as they all emphasize active engagement, interdisciplinarity, creativity, emotional intelligence, and learner autonomy. Their implementation in technical higher education can significantly strengthen the development of engineering competencies, ensuring that future engineers are not only technically proficient but also adaptable, innovative, and socially responsible professionals.

The author's approach to contemporary educational practices appears highly valuable and timely to us. Nevertheless, when implementing the STEAM model, a distinctive feature emerges: the integration of cultural-artistic dimension into the technical discipline environment. This process requires not only technological innovation but also pedagogical sensitivity to the humanistic dimensions of learning.

Therefore, we propose our own definition of educational technologies that incorporate cultural and artistic aspects. We define them as an effective and comprehensive psycho-pedagogical synthesis of methodological approaches, organizational forms, and didactic tools, grounded in cultural and educational values, as well as in both innovative and traditional achievements of pedagogy. These technologies remain effective but evolve dynamically in response to technological progress, students' needs, psychological characteristics, and the specific professional orientation of an institution.

In this view, such technologies are implemented within the educational process of technical universities to promote the acquisition of knowledge, the development of practical skills and abilities, and the cultivation of competencies essential for professional work, self-development, and self-actualization of future engineers. By embedding artistic and cultural dimensions into the technical learning space, they contribute to the formation of reflective, ethically responsible, and socially conscious professionals capable of harmonizing innovation with human values.

Methodology for Integrating the STEAM Approach into the Teaching of Humanities in Technical Universities

In our practice of teaching humanities disciplines at a technical university, we implemented a variety of educational technologies to integrate STEAM approaches into the educational process. Particular attention was devoted to integrating cultural and artistic components into technical education. Our pedagogical work combined both innovative and traditional educational technologies, selecting those that proved most effective in helping students acquire new knowledge.

We placed a strong emphasis on interactive (active) educational technologies, including:

– non-simulative developmental methods (problem-based and interactive lectures, seminars, problem discussions, brainstorming sessions, debates, analyses, workshops, expert surveys, small-group work methods);

– simulative developmental methods (case studies, solving production-related tasks, simulation exercises, simulation training);

– game-based technologies (business and role-playing games, game-based project design);

– project-based learning (group project activities);

– training-based formats (group training sessions, classes incorporating training elements) (Hrechanovska, 2020).

While this set of educational technologies can be used in teaching virtually any discipline, our approach went further by integrating the Cultural and Educational Art Center (CEAC) located at Vinnytsia National Technical University into the study of humanities. The CEAC is a complex of museums dedicated to fine and decorative-applied arts. It includes eight educational art laboratories covering various themes such as classical art, decorative arts, modernism, sculpture, socialist realism, and folk iconography. We regarded the CEAC as an essential element in integrating STEAM approaches within the educational process of the technical university.

The integration of STEAM principles was implemented during the study of the course "Psychology of Personality" with second-year bachelor's students. The challenge in teaching this discipline lies in the fact that technically oriented students often lack interest in subjects they perceive as unrelated to their future professional activities. This often creates barriers to their ability to recognize the interconnection between humanities, technical disciplines, and cultural knowledge. To address this, we attempted to link students' professional (technical) knowledge with psychological and cultural understanding.

Since "Psychology of Personality" is an elective course, it can be assumed that the integration of STEAM elements occurred among students who were already interested in psychology. Our actions, therefore, aimed to help them perceive how psychological and cultural knowledge interrelates with their professional training, fostering a holistic and human-centered perspective within technical education.

The purpose of the proposed tasks was to stimulate students' desire to deepen, develop, apply, and integrate diverse knowledge and skills in practice, incorporating an artistic component into this process. The central theme chosen for the activity involved exploring personality traits and temperaments as psychological characteristics of the individual. Although students already possessed basic psychological knowledge on this topic, it was essential to further develop their understanding of the relationship between psychological concepts and their future professional field.

During the completion of the tasks, the educational and art laboratories of the Cultural and Educational Center (CEC) were actively used. The topic of the activity was "Psychological Modeling: Creating Portraits of Temperaments." The task consisted of several stages and extended over four class sessions.

The first stage was organizational, involving the formation of mini-groups of five to eight students. This step was crucial, as it later enabled the observation of the students' ability to work collaboratively, interact effectively, perform tasks independently, and take responsibility for the team's collective results.

Each group, through a random draw, selected the type of temperament they would study (sanguine, choleric, phlegmatic, or melancholic). At this stage, the groups were tasked with creating a mind map summarizing psychological research related to human temperaments. To ensure diversity, the topics were discussed so that no two groups would repeat the same theme. For example:

– one group analyzed historical perspectives (psychologists who studied temperament and its characteristics);

– another examined the biological foundations of temperament;

– a third explored major theoretical approaches to temperament;

– a fourth analyzed representations of temperament in culture films, cartoons, books, or video games where character temperaments are vividly portrayed.

During the task, the use of digital tools for creating mind maps was prohibited. The maps were drawn manually, using a variety of artistic materials, including pencils, markers, and collage techniques. The activity was designed to activate students' creativity, reveal their artistic potential, and encourage autonomous work without the use of technology. We humorously referred to this assignment as "cave drawings," since some students considered the use of pencils outdated or unnecessary.

At certain stages, this analog format caused difficulties, for instance, in selecting appropriate colors or images, as students had to complete the assignment without digital programs or ChatGPT assistance. Nevertheless, these challenges became an important part of the learning process, promoting reflection, problem-solving, and creative collaboration.

In the final phase, all mind maps were combined into one large composite map with four main branches, each representing one temperament type. Every group presented its work, allowing students to see the studied topic from multiple perspectives and to gain a deeper understanding of its complexity and interconnectedness.

The second stage of the assignment took place in the educational art laboratories of the Cultural and Educational Center, designed as an art-based educational exploration (a guided educational tour) followed by independent research. Building upon their prior knowledge, students were asked to select four paintings that, in their opinion, best represented the type of temperament assigned to their team and reflected the psychological characteristics associated with it. This task was completed independently, without any direct guidance from the instructor.

Students not only chose a painting but also delivered a short presentation, introducing the artist and the history behind the artwork, explaining their interpretation of the image, analyzing the use of color, and justifying their perception of how the artwork corresponds to a specific temperament type. In this way, they transformed the activity into a mini-case study that combined cultural content, elements of personality psychology, and modern digital tools, thus embodying the essence of the STEAM methodology. Each mini-case was presented to the entire group, followed by a discussion and reflection session to analyze the experience and consolidate the learning outcomes.

The third stage of the assignment involved utilizing digital technologies. Each team was asked to confidentially select one painting from among the eight art laboratories of the Center. The content of the chosen painting remained unknown to their opponents but was meant to represent the temperament type assigned to the rival team. The task for each group was to create a list of key descriptive words for the painting they had selected and communicate them to their opponent team. The opposing team then had to generate an image based on those keywords using AI-based image generation tools.

Students were not restricted in their choice of software, though most used freely accessible programs such as DALL·E (by OpenAI), Canva (with AI Generator), and ChatGPT. The teams then displayed their generated images and tried to guess which original painting they represented, identifying the artist, the laboratory where it was located, and discussing whether the image accurately matched the assigned temperament type.

Such assignments not only foster creativity but also develop the ability to describe situations precisely and convey information effectively. During the process, the instructor emphasized that no description is ever completely objective: each speaker interprets reality in their own way, and each listener perceives it differently. Moreover, information transmitted through digital tools is not always reliable, and therefore, it must be verified using multiple sources.

Particular attention was drawn to the fact that answers or materials produced by ChatGPT, used by approximately 87% of the students (according to a survey), are not always accurate or scientifically valid. Hence, genuine research and inquiry-based learning should be grounded in personal investigation, critical analysis, and the use of diverse and credible information sources.

The fourth assignment, titled "Portrait of Temperament: Art Through Science", combined both individual and group work and incorporated an interactive STEAM-based approach. The individual task involved identifying one's own personality traits and temperament using a simplified and adapted version of the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1963), which consists of 57 questions and measures the personality dimensions of extraversion, introversion, and neuroticism. Based on mathematical calculations and the obtained results, students plotted their coordinates on the axes of introversion-extraversion and emotional stability–instability, locating their position on the chart (Methodical Guidelines for Independent and Individual Work in the Course "Psychology of Personality," 2024, pp. 40-43).

After determining their temperament type, students were asked to produce a visual art image representing their temperament through creative activation. The format of the artwork was not limited: students could use digital tools or traditional artistic media. The task aimed not at drawing a self-portrait but rather at conveying one's inner emotional and psychological state, resulting in a wide variety of interpretations.

A key element of the assignment was confidentiality: artworks were submitted to the instructor through the university's online learning platform and were not revealed to the class until the presentation. During the session, the instructor displayed the works without identifying the authors, and students had to guess who created each image and identify the author's temperament type. This exercise encouraged students to learn more about each other, to better understand the psychological nuances of their peers, and to develop the skill of constructing psychological profiles of their peers.

The proposed active learning technology integrates multiple teaching methods and techniques, including mind mapping, discussion, art-based educational explorations (guided educational tours), debates, creative activation methods, and reflective thinking techniques. Such a diverse implementation of methods and technologies requires a specialized system of assessment. We support the view that for interactive classes to be effective, separate evaluation criteria must be developed for each session, corresponding to the chosen educational technologies, since identical criteria cannot be applied to, for instance, both game-based and training-based technologies.

Considering that the activity was designed according to the STEAM approach, we employed a method that had already demonstrated strong results in previous research: peer assessment. This method involves student-to-student evaluation based on instructor-defined criteria, conducted asynchronously, and serves to enhance the quality and responsibility of students' work (Hrechanovska, 2020, p. 242).

The effectiveness of this method has also been confirmed by international research. Wouter Groeneveld et al. (2020) emphasize that peer assessment is a popular and effective tool for the in-depth evaluation of individual contributions in group projects, noting its positive impact on self-assessment, motivation, and skill development. Their two-year longitudinal study found that "students tend to assess their project more accurately for some, though not all, evaluation criteria after participating in a peer-assessment session; they report higher motivation to continue improving their work, and the correlation between motivation and time spent on the project increases. These findings suggest that peer assessment can have a lasting positive effect on students' reflective abilities and, consequently, on their lifelong learning skills" (Groeneveld et al., 2020).

Of course, the use of Peer Assessment also presents certain challenges, as pointed out by Ashenafi et al. (2015). These researchers, analyzing issues in modern peer evaluation practices, highlight that instructors employing this method should establish interdisciplinary connections, for example, with computer science, which is particularly crucial for classes conducted within the STEAM framework.

The main objective of assessment within the STEAM-based learning model was to delegate the evaluative function to students, while the instructor assumed the role of moderator and facilitator. According to predefined criteria, students evaluated both the performance of competing teams and the individual contributions of members within their own teams. Each task was graded on a five-point scale, and the final score was calculated as the arithmetic mean of all obtained values.

Our previous research (Hrechanovska, 2020, p. 241) demonstrated that "when students evaluate the work of their peers, they apply specific assessment criteria and provide feedback to clarify what needs improvement. Evaluation involves rating scales or various types of explanations and rules." Thus, the peer-assessment method proved to be an effective tool for developing responsibility, analytical thinking, and academic integrity, as it encourages students to engage in the educational process not merely as performers but also as active analysts of learning outcomes. This approach enhances student involvement in learning through the STEAM framework, engaging not only cognitive but also psychological and emotional processes of the individual.

Upon completing the tasks and assessment activities, a reflective thinking discussion was held to analyze the effectiveness of the learning process and the quality of task completion. Students shared their impressions and answered questions from a brief survey. A total of 178 second-year students from various faculties where the elective course "Psychology of Personality" was taught participated in the survey.

The collected data revealed the following results:

To the question "How interesting was the class for you?", 31% responded "very interesting," 45% – "interesting," 18% – "somewhat interesting," and 6% – "not interesting."

In response to "Was the combination of creative tasks and scientific approaches (STEAM) useful?", 49% answered "yes," 41% – "partially," and 10% – "no."

When asked about the challenges they encountered, 82% of respondents reported difficulties completing certain tasks. The main reasons cited were:

– the challenge of performing tasks without relying on computer programs;

– difficulties in collaborating with team members they were not personally close to;

– and peer assessment, which required them to justify their evaluations and engage in face-to-face dialogue with other students.

As the students noted, communicating through chats or social media felt much easier, as it allowed them to express opinions without direct confrontation. They commented that "in chats, you can end the conversation whenever you want and ignore other people's opinions." Such statements reveal that direct interpersonal communication still poses psychological barriers for many students, limiting their ability to express themselves fully. This also highlights a lack of confidence and insufficient preparation for teamwork, particularly in areas such as conflict prevention, acceptance, and resolution.

Despite these challenges, when asked, “Would you like to have more classes like this?”, 89% of students responded “yes,” while 11% were “unsure.” These findings clearly demonstrate a high level of student interest in the continued implementation of STEAM-based learning approaches in higher education.

In the long-term perspective of implementing the STEAM approach into the educational process, we have proposed a series of pilot binary classes within an innovative integrative course titled “Cultural Mathematics” (an original author’s development). The course is designed to be team-taught by several instructors and integrates the subjects that constitute the STEAM model. It is built upon interactive (active) teaching technologies that promote both engagement and interdisciplinary synthesis.

The study of this course aims to deepen students’ understanding of higher mathematics by interpreting mathematical concepts through the lens of cultural phenomena and their interrelation with technology, science, and engineering. Moreover, it encourages reflection on how these interconnections have shaped human development across various domains. The course seeks to form students’ ability to apply mathematical and cultural knowledge in their professional fields, fostering both analytical precision and cultural awareness.

Among the proposed topics currently under development are:

– Culture + Mathematics = ? “The Map of the Discipline Cultural Mathematics” - an introductory interactive lecture;

– The Mystery of DNA Numbers;

– Art, Philosophy, and the Coordinate System: Commonalities and Differences (scalar, vector, and tensor quantities; the Cartesian coordinate system on the plane - analytical geometry);

– The Concept of the Abstract in Cultural Mathematics (abstract linear spaces, abstractionism across art forms - analytical geometry);

– The Phenomenon of the Attractor (differential equations);

– Fibonacci Numbers and the Golden Ratio in World Cultures;

– A Cultural Perspective on the Development of Civilizations Through Mathematical Statistics;

– The Model as an Abstract Representation of Reality (mathematical and artistic modeling);

– The Probable and the Improbable (theory of probability);

– Random Phenomena as Patterns in the Cultural Development of Civilizations (mathematical statistics in experimental analysis).

The proposed course, along with its topics, teaching methods, and the integration of artistic and scientific dimensions, represents a significant step toward embedding the STEAM approach into the educational process of technical universities. It fosters a humanized vision of engineering education, where analytical thinking coexists with creativity, cultural literacy, and reflective understanding of the world.

Conclusions

Within our teaching practice, the implementation of the STEAM approach in work with students particularly through the integration of the educational-artistic laboratories of the Cultural and Educational Center revealed a set of effective educational technologies, including: project-based learning (individual and group projects addressing real-world issues); critical thinking technologies (media analysis, debates, ethical dilemmas); coaching and facilitation (interaction between educational participants through inquiry, support, and intrinsic motivation); interactive (active-learning) technologies (active learner engagement, small-group work, role-playing, situation modeling, guided educational tours); gamification and game-based learning (elements of gamified activities, quests, training games); media education technologies (production of videos, podcasts, social projects); social design technologies (volunteering, charity, environmental initiatives); case-based learning (analysis of real or simulated professional situations); and psychological training technologies.

Nevertheless, combining and applying such diverse teaching methods within the framework of the STEAM approach presents several challenges, which we have identified as follows:

Resistance to traditional systems: Teaching practices are still dominated by traditional forms focused on knowledge reproduction rather than application. Low motivation among some instructors and students is linked to habitual teaching routines. Effective STEAM integration requires thorough instructor preparation (lesson design, evaluation strategies) and student readiness, both intellectually and motivationally.

Insufficient readiness of teaching staff: There is a shortage of professionals capable of integrating cultural-artistic dimension into technical environments and applying interdisciplinary teaching methods. Many students still lack the skills needed for project-based, research-oriented, and creative learning, as well as experience with peer assessment.

Limited material and methodological resources: The absence of fully equipped STEAM laboratories, workshops, and digital platforms hampers the implementation of project-based and integrative learning. Access to quality STEAM methodologies and adapted educational materials for technical higher education remains insufficient.

Challenges of digitalization: Some instructors and students have inadequate digital literacy, and outdated ICT tools are still being used, which do not meet the requirements of modern STEAM environments. The ability to connect artistic and cultural content with digital technologies also remains underdeveloped.

Difficulties in building teamwork and assessing outcomes: Not all students have experience in collaborative or creative group work. When teams form independently, unequal participation often occurs, leading to challenges in applying peer assessment. Moreover, assessing soft skills, creativity, and innovation remains a complex task.

Cultural barriers to the artistic component: The cultural and artistic dimensions of STEAM are often undervalued in the training of future technical professionals and perceived as “additional” or secondary, which reduces motivation to integrate them meaningfully into the curriculum.

Hence, our work represents an attempt to implement and integrate the STEAM approach into the training process for future technical specialists. While the proposed methodology may not be universally applicable across all technical universities or fully meet expectations regarding its implementation, it nonetheless demonstrates a viable and innovative direction. If the focus were solely on the STEM model, fewer challenges of integration would emerge; at the same time, integrating the cultural-artistic dimension into the technical domain requires not only addressing the above challenges but also achieving broader societal recognition of the importance and necessity of the STEAM approach in shaping the engineers of the future.

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