МЕТОДОЛОГИЯ И ТЕХНОЛОГИЯ ПРОФЕССИОНАЛЬНОГО ОБРАЗОВАНИЯ

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MODERN EDUCATIONAL LANDSCAPE AND STEM APPROACH TO EDUCATION: TRANSFORMATION OF TRADITIONAL ENVIRONMENTS FOR TRAINING ENGINEERS

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Abstract

Relevance. Avalanche-like technologies that require high-quality engineering education for their development and implementation, for the sustainability of the economy, are in dire need of a comprehensive way to solve super-complex tasks and problems. The emerging problems sometimes cannot be solved by the old methods within the existing distinctions. The relevance of the study is caused by the need to search for new approaches and educational technologies in the system of engineering education.

Purpose. The purpose of the work is to consider new, interconnected and mutually dependent resources that feed the idea of continuity of professional engineering and technological education.

Research methods. The author's research uses such methods as: analysis of theoretical ideas about engineering economics, technological education, transdisciplinarity and continuity of education for an engineer of the future; analysis of pedagogical and research experience in the field of technological education; a local expert survey conducted in December 2021 in an online format – to identify the problems and opportunities of today's popular STEM education; content analysis of answers to open-ended questions offered to respondents working in STEM technology.

Scientific novelty/theoretical and/or practical significance. Conclusions are drawn about the need to reflect on the special equipment and responsibility in relation to the technological educational space.

Results. Based on the research, the article presents a view on the duality of training engineers of a new formation, on combining their theoretical training with the cultivation of the ability to practically solve production problems. It is shown that transdisciplinarity sets the most important vector for the development of technological education.

Conclusions. Integration, transnationalization, information openness, commercialization and digitalization of all aspects of life place new demands on the education, development, and training

of an engineer. In this regard, strategies, values, meanings and behavior patterns of subjects of engineering education await new understanding and analysis.

***Keywords*:** continuing engineering education; STEM approach; educational space; innovative engineering design; transdisciplinarity; learning environment; educational landscape.

СОВРЕМЕННЫЙ ОБРАЗОВАТЕЛЬНЫЙ ЛАНДШАФТ И STEM-ПОДХОД В ОБУЧЕНИИ: ТРАНСФОРМАЦИЯ ТРАДИЦИОННЫХ СРЕД ПОДГОТОВКИ ИНЖЕНЕРОВ

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Аннотация

Актуальность. Лавинообразно появляющиеся технологии, которые требуют для своих развития, внедрения и устойчивости экономики качественного инженерного образования, остро нуждаются в комплексном способе решения сверхсложных задач и проблем. Возникающие задачи порой не могут быть решены старыми методами в рамках существующих различий. Актуальность исследования вызвана необходимостью поиска новых подходов и образовательных технологий в системе инженерного образования.

Цель работы – рассмотреть новые, связанные между собой и зависимые друг от друга ресурсы, питающие идею непрерывности профессионального инженерного и технологического образования.

Методы исследования. В исследовании использованы такие методы, как: анализ теоретических представлений об инженерной экономике, технологическом образовании, трансдисциплинарности и непрерывности обучения инженера будущего; анализ педагогического и исследовательского опыта в сфере технологического образования; локальный экспертный опрос, проведённый в декабре 2021 г. в онлайн-формате для выявления проблем и возможностей популярного сегодня STEM-образования; контент-анализ ответов на открытые вопросы, предлагаемые респондентам, работающим в технологии STEM.

Научная новизна / теоретическая и/или практическая значимость. Сделаны выводы о необходимости рефлексии особых оснащённости и ответственности по отношению к технологическому образовательному пространству.

Результаты исследования. В статье на основе исследования представлен взгляд на дуальность обучения инженеров новой формации, на совмещение их теоретической подготовки с формированием способности к практическому решению задач производства. Показано, что трансдисциплинарность задаёт важнейший вектор развития технологического образования.

Выводы. Интеграция, транснационализация, информационная открытость, коммерциализация и цифровизация всех сторон жизни предъявляют новые требования к воспитанию, развитию, обучению инженера. В связи с этим стратегии, ценности, смыслы и модели поведения субъектов инженерного образования требуют нового понимания и анализа.

Ключевые слова: непрерывное инженерное образование, STEM-подход, образовательное пространство, инновационное инженерное проектирование, трансдисциплинарность, среда обучения, образовательный ландшафт

INTRODUCTION

The "Silver Bullet" is a vivid symbol of the universal way of solving super-complex tasks and problems. Avalanche-like technologies that require high-quality engineering education for their development and implementation, for the sustainability of the economy, are in dire need of a super-method like a "silver Bullet". Today, the ideologists of the educational sphere are talking more and more about the duality of training engineers of a new formation, about combining their theoretical training with the cultivation of the ability to practically solve production problems. Transdisciplinarity sets the most important vector for the development of technological education [7]. The boundaries that once firmly separated one area of knowledge from another are becoming almost invisible today. Disciplinary limits are less and less rigid and hermetic, their plasticity increases. The consequences of spreading the principle of transdisciplinarity are: the latest areas of scientific research (they increasingly appear at the intersection of different subject areas), the work and real achievements of hybrid experimental teams, powerful and bright design solutions [14]. At the same time, transdisciplinary concepts become the basis for innovative engineering design [3].

The practical implementation of the transdisciplinary approach is STEM education. S-science (science), T-technology (technology), E-engineering (engineering), M-mathematics (mathematics) – this is how this abbreviation, which is popular today, stands for. The rapid spread of the STEM approach is explained, firstly, by the desire to oppose the isolation of academic disciplines with the integration of scientific and practical knowledge; secondly, the desire to oppose the growth of facts and "fragmentary" information within each subject area with the living logic of transdisciplinary knowledge [1]. It is no secret that today's education at school and university is methodically directed towards a test method of testing knowledge [5]. With this approach, skills and abilities are rarely remembered, namely, they ensure the application of knowledge in multidisciplinary practice, make engineering and technology professions closer and more understandable for young people, increase their awareness and provide an opportunity to make a career in the engineering and technical field [8]. In order to serve a "voluminous" practice, knowledge itself must be "voluminous", and not just filled with numerous facts and information from various subject areas.

MAIN PART

Purpose and objectives of the study. Avalanche-like technologies that require high-quality engineering education for their development and implementation, for the sustainability of the economy, are in dire need of a comprehensive way to solve super-complex tasks and problems. The purpose of the work is to consider new, interconnected and mutually dependent resources that feed the idea of continuity of professional engineering and technological education.

Methodology and research methods. As a methodological basis for the analysis of theoretical and practical aspects of engineering education and the proposed conclusions, we used the scientific content of the official websites of educational Russian and foreign institutions of secondary and higher education. We focused on the presence in the content of their educational activities of the terms "engineering economics", "engineering education", "transdisciplinarity", "STEM approach in education", "innovative engineering design".

Organization of the study and course of work. Of great interest were the opinions of experts (teachers, teachers of secondary specialized and higher educational institutions), who daily face the problems and opportunities of the STEM approach in their educational activities. In the author's study, we used such methods as: a) analysis of theoretical ideas about engineering economics, technological education, transdisciplinarity and continuity of education for an engineer of the future; b) analysis of pedagogical and research experience in the field of technological education; c) a local expert survey conducted in December

2021 in an online format – during the quarantine period, the acute problems of the STEM approach that is popular today in engineering education manifested themselves especially clearly; d) content analysis of answers to open questions offered to respondents. Fifty-three survey participants answered a series of the following questions: What is the essence of STEM technology? Why is STEM education so relevant and promising? What are the benefits of a STEM approach to learning? How is STEM education changing the modern educational landscape? How the educational landscape influences the formation of a picture of the world of an engineer of the future.

Research results. The overwhelming majority of participants in our survey almost agreed (89% of respondents) that the basis of STEM technology is an engineering approach to any invention. To obtain, for example, a prototype, a competent design is a prerequisite. This means that it is not enough just to invent, to see an object in a mental plan – an object that does not yet exist must be described in engineering language. It is necessary, firstly, to set the task in such a way that the result obtained corresponds to the goal. Secondly, carefully explore the implementation possibilities, which requires complex knowledge from different disciplines. This is how the student's natural-scientific picture of the world is formed and constantly enriched. That is, the essence of STEM technology is in the inevitable "immersion" of students, on the one hand, into the theoretical foundations of the discipline, and on the other hand, into understanding its application in practice, in the situation "here and now".

In many regions of Russia, as noted by 67% of experts, educational programs using STEM technology are gaining momentum. Technology companies are creating STEM centers based on higher education institutions and technology parks. Here, students not only acquire new knowledge and skills, but also participate in scientific and practical work, in specific engineering studies and projects [10]. Olympiads, robofests, tournaments are both centers for demonstrating and developing practical engineering skills, and competitive platforms that serve as a "social lift" to prestigious technical higher educational institutions.

STEM education, in the end, allows a completely different look at the entrenched education system and claims to be the very "silver bullet" in education that is required for the sustainable development of the country's economy [11].

Engineering design using STEM technology is a popular trend today [12]. A huge bet is placed on it, since not only the natural science component is being strengthened, but innovative technologies are being actively introduced into the study of other disciplines, including the humanities and arts. This was noted by 73% of those who answered the questionnaire. It develops the much-needed creativity of thinking of students. At the same time, the implementation of a STEM project in practice is very important – science and art are synthesized in an engineering invention useful for everyday life [6]. The relevance, useful significance of the approach is noted by more than three-quarters (78%) of the respondents.

The differences between STEM education and a traditional school are significant: the fact is that the form of presenting educational content in an ordinary school is centered around the teacher, while in STEM techniques, the main thing is to solve the problem not in theoretical terms, but in practice, by trial and error.

As noted by five-sixths of those who answered the third question of our questionnaire (84% of respondents), STEM education has enormous advantages: it combines project-based and multidisciplinary learning methods, that is, we are dealing with the desired integrated form; it makes it possible to apply the acquired knowledge in real activities when creating a specific product that is in demand in life; critical and, which is extremely important, independent thinking develops, which is difficult to form in a theoretical approach; self-confidence appears, healthy self-esteem is strengthened, as the idea is brought to life; working in a team, students learn to substantiate their position in a discussion, to jointly reach concrete decisions; inter-

est in engineering specialties is growing, since the technical solution is carried out using the achievements of science and cutting-edge technologies, independently (or in a team) and practically on a turnkey basis; the idea of the duality of engineering education is supported, when there is a direct path from education to career; a platform is being created for a rapid technological upsurge, which is very important for the sustainable development of the country's economy.

Discussion of the results of the study. Of great interest is the term, which for scientific pedagogical literature is somewhat figurative, even metaphorical, but, nevertheless, today it occurs quite often even in strict scientific discourse. The term "educational landscape" is used in conjunction with continuous engineering education. In the course of permanent learning, a person inevitably interacts with the outside world, he grows physically, changes intellectually, emotionally, spiritually, develops ontogenetically and phylogenetically. The educational landscape is a multi-dimensional, interactive, multi-sensory, complex and extremely dynamic construct against which informal, non-formal and formal education unfolds. It has an aesthetic and ecological dimension. The educational landscape includes factors and conditions that promote growth and development, as well as hinder them. Both social and biological life exist due to the transmission of knowledge. Moreover, this transmission takes place not only in institutions specially designed for this, but, first of all, through communication between elders and younger ones. The new generation learns through live communication with adults to think, act, feel, overcome, etc. Education is a vital necessity for a particular person and society as a whole, in the name of the continued existence of the individual and society. By educating, humanity saves itself. And here the very process of living together is of great importance, and not just formal education at school.

The role of the social environment in transferring the experience of generations cannot be exaggerated. The social environment forms the intellectual structures and emotional attitudes of behavior, this happens in joint activities. The life landscape, accordingly, exercises its educational and upbringing influence, and this often happens regardless of clearly set goals, and sometimes in spite of them, almost unconsciously [2].

The subconscious influence of the landscape is so great that it manifests itself in the way of thinking, character traits, forms of speech, and lexical structure. As for speech and vocabulary, researchers have long established: in acute excitement, panic states, strict speech turns learned at school can fall out of consciousness, and a person returns from hopelessness to the language learned in childhood when communicating with close significant adults.

"Correct manners" appear, in general, due to the repeated reproduction of habitual reactions in response to habitual stimuli. And it is unlikely that constant instructions and the benefits of manners, and not even knowledge of how to behave correctly, form a style of behavior. The main factors are still the atmosphere in which the child, the future "techie", and the spirit of the environment are formed.

The formation of good taste and aesthetic perception of the world, following the same logic, occurs due to the fact that a person from childhood is surrounded by graceful objects, proportional in shape, decided in a harmonious color combination. Vulgar, clumsy, oversaturated or, on the contrary, meager landscapes spoil and impoverish taste, deprive a person of a sense of beauty.

Today's European training and education agendas in recent years have repeatedly called on school leaders to adapt to the ever-changing landscape of diverse forms of education [13]. A significant transformation of traditional educational institutions and environments is predicted, as well as a change of players on educational platforms. The need to help students navigate among inexhaustible educational resources is emphasized.

Mention of the educational landscape today is often found in public speeches, interviews with leading publications and in a selec-

tion of documents from the UK Department of Education, traditionally not in a hurry to immediately follow fresh trends, which additionally testifies to new trends and the irreversibility of the development of the engineering educational space.

In German-speaking Germany and Switzerland, the concept of "lernlandschaft" is included in the concept of "learning environment". Thus, space is allocated outside the classrooms and classrooms. This is, as a rule, a large area in which each student, in accordance with individual tastes and interests, equips his workplace. Interior items, school equipment (desks, shelves, blackboard, etc.) in such a landscape are mobile, they are easy to move. With such a "free" entourage, methodologists believe, it is much easier to enter the discipline of the curriculum, the subject topic, the module than in a traditionally decorated classroom.

In German, there is also a synonym for the concept of "lernlandschaft". This is the phrase "bildungslandschaft". In this case, we are talking about creating a space of diverse and equal educational opportunities, a territory that meets the most sophisticated tastes of students. Of course, the arrangement of such a territory involves the development of an educational structure in order to simplify the "transfer" from one form of education to another. For example, a project to improve the educational landscape may result in a network of schools collaborating with universities, with additional infrastructure in the form of cultural, sports and other educational organizations [9]. Of course, the creation of such conglomerates greatly increases the educational and career opportunities of young people. And if such complexes also have centers for information, career guidance, various types of counseling, effective assistance, if a conscious need for harmonious development is being formed on this territory, then in this case it can be argued that a motivational approach to learning is being implemented here, and this landscape is aimed to the future.

A management system focused on the development of the effectiveness of educational landscapes uses methods and tools for assessing and improving quality in order to direct the educational proposals of the region to what is actually referred to when they talk about education: to develop the knowledge and competencies of people in the region. A discussion platform is being created for participants in the education system in order to develop promising strategies and necessary activities with the help of peer assessment on the spot.

Studying international territorial initiatives in the field of education, sometimes you come across unique lexical images. Take, for example, "square kilometer of education". This is a series of German educational programs and a series of socially significant events for children and teenagers. They are carried out under the slogan: "No child should be lost to society." How can one not recall Anton Semenovich Makarenko, who wrote that the educational process takes place not only in the classroom, but literally on every square meter of our land? The designed educational space does not and should not coincide exactly with the territory of the educational institution, but is an indispensable part of the space of the country's socio-cultural life. At the same time, the basis of the educational space of the community of children and adults is creative, spiritual, moral work. Or is it another dimension?

In many progressive countries, there is a general social attitude towards expanding the area of education for the population, transforming the educational space, the learning environment, and the educational landscape [15]. It is about developing the individual by going beyond formal education and a specific formal institution. It is no coincidence that dreams of a school without walls, a school-park, learning online appear. Learning communities are being created that are transforming the educational landscape. Against this background, new conceptual ideas about the real and possible territory of continuous engineering education are being formed in the world. Moreover, in this process, largely due to the national specifics and educational tradi-

tions of each of their countries, general trends are noticeable.

CONCLUSION

The penetration of the ideas of globalization, democratization, liberalization and scientific and technological progress into the cultures of different countries brings together social requirements for the educational space, learning environment, and landscape.

The educational landscape exercises its educational and educational influence, forms a picture of the world of an engineer of the future, and this often happens regardless of clearly set goals, and sometimes even contrary to them. The subconscious influence of the landscape is so great that it manifests itself in the way of thinking, character traits, forms of speech, and lexical structure.

The list of spatial characteristics of engineering education is constantly growing and changing. Conceptual ideas about space are also constantly evolving and transforming. We are witnesses and active participants in the consistent deepening of understanding of any territory where educational processes unfold: from a specific place, limited by physical boundaries, in which they teach and study, to the global open information and educational space of the modern world [4].

STEM learning has enormous advantages: it combines project-based and multidisciplinary learning methods, that is, we are dealing with the desired integrated form; it makes it possible to apply the acquired knowledge in real activities when creating a specific product that is in demand in life; critical and, which is extremely important, independent thinking develops, which is difficult to form in a theoretical approach; self-confidence appears, healthy self-esteem is strengthened, as the idea is brought to life; working in a team, students learn to substantiate their position in a discussion, to jointly reach concrete decisions; interest in engineering specialties is growing, since the technical solution is carried out using the achievements of science and cutting-edge technologies, independently (or in a team) and practically on a turnkey basis; the idea of the duality of engineering education is supported, when there is a direct path from education to career; a platform is being created for a rapid technological upsurge, which is very important for the sustainable development of the country's economy.

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