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Use of cluster technologies in enhancing the professional training of future engineers

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Annotatsiya. *This article is devoted to highlighting the theoretical, methodological and practical aspects of using cluster technologies in the formation of professional training of future engineers in accordance with modern requirements. The article analyzes the pedagogical essence of cluster technology, its role in the educational process and its potential for developing professional competencies of future engineers on a scientific basis. It is argued that through the cluster approach, students can systematically and logically master knowledge, work on the basis of interdisciplinary integration, combine theory and practice, and gain a deep understanding of complex technological processes.*

Kalit so‘zlar: *cluster technology, engineering education, professional training, competence, innovative pedagogy, digital learning environment.*

Использование кластерных технологий для повышения качества профессиональной подготовки будущих инженеров

Аннотация. *Данная статья посвящена освещению теоретико-методических и практических аспектов использования кластерных технологий в формировании профессиональной подготовки будущих инженеров на основе современных требований. В статье на научной основе анализируется педагогическая сущность кластерной технологии, её роль в образовательном процессе и потенциал в развитии профессиональных компетенций будущих инженеров. Также обосновано, что посредством кластерного подхода студенты могут системно и логически усваивать знания, работать на основе междисциплинарной интеграции, сочетать теорию и практику, глубоко понимать сложные технологические процессы.*

Ключевые слова: *кластерная технология, инженерное образование, профессиональная подготовка, компетентность, инновационная педагогика, цифровая среда обучения.*

Bo‘lajak muhandislarning kasbiy tayyorgarligi sifatini oshirishda klaster texnologiyalaridan foydalanish

Annotation. *Mazkur maqola zamonaviy talablar asosida bo‘lajak muhandislarning kasbiy tayyorgarligini shakllantirishda klaster texnologiyalaridan foydalanishning nazariy-uslubiy va amaliy jihatlarini yoritishga bag‘ishlangan. Maqolada klaster texnologiyasining pedagogik mohiyati, uning ta’lim jarayonidagi o‘rni hamda bo‘lajak muhandislarning kasbiy kompetensiyalarini rivojlantirishdagi salohiyati ilmiy asosda tahlil qilingan. Shuningdek, klaster yondashuvi orqali talabalar bilimlarni tizimli va mantiqiy o‘zlashtirishi, fanlararo integratsiya asosida ishlashi, nazariya va amaliyotni uyg‘unlashtirib, murakkab texnologik jarayonlarni chuqur anglab yetishi mumkinligi asoslab berilgan.*

Keywords: *klaster texnologiyasi, muhandislik ta’limi, kasbiy tayyorgarlik, kompetentlik, innovatsion pedagogika, raqamli ta’lim muhiti.*

INTRODUCTION

In our country's education system, along with the acquisition of theoretical and practical knowledge by future engineering specialists within the framework of disciplines, there is a need to equip them with professional competencies in accordance with world standards and to improve the system of professional development. As noted by the President of the Republic of Uzbekistan Shavkat Mirziyoyev in his Address, “The main strategic direction of the education system is to create opportunities for young people to acquire modern professions; in this context, it is necessary to remodel pedagogical processes in accordance with labor market needs and ensure the integration of education and employment”. In particular, the fact that up to 50% of school graduates enter the labor market without professional training negatively affects the level of employment and economic efficiency; therefore, the development of educational and methodological complexes based on the competency-based approach, as well as the improvement of practical skills, is of great importance[1]. In recent years, reforms in the field of education in our republic are creating a normative basis for improving the quality of training specialists in this field based on cluster approaches. “Raising the content of higher education to a qualitatively new level, establishing a system for training highly qualified personnel who can make a worthy contribution to the sustainable development of the social sphere and economic sectors, and find their place in the labor market” were set as a priority [2].

A modern engineer, along with deep professional knowledge, must have analytical thinking, quick and sound decision-making in problem situations, an innovative approach, and the skills of effective teamwork. Globalization, digitalization, and the rapid development of industrial technologies are bringing fundamental changes to all spheres of social life, including the higher education system. In particular, the issue of training engineering personnel is one of the important factors determining the economic development, innovative potential and competitiveness of countries. The increasing complexity of modern production processes, the widespread introduction of automation, artificial intelligence and digital technologies require future engineers not only theoretical knowledge, but also a high level of practical training, creative thinking and the ability to make independent and quick decisions in problem situations. In the process of training engineers in higher educational institutions, traditional teaching methods are often limited to providing information and do not provide sufficient active participation of students. As a result, graduates face difficulties in adapting to real production conditions. Therefore, there is a need to introduce innovative pedagogical technologies into the educational process, modernize the content of education and improve

teaching methods. In this regard, cluster technology is recognized as an important pedagogical tool.

Cluster technology is aimed at learning knowledge in a systematic, logical and interconnected way, activating the thinking process of students. In this approach, the student appears not only as a receiver of ready-made information, but also as an independent seeker, analyzer and generalizer of knowledge. Especially in engineering disciplines, the cluster method helps to deeply understand their components, functions and interrelationships when mastering complex technological systems, processes and models. In addition, cluster technology enhances interdisciplinary integration, that is, it creates an integral connection between mathematics, physics, computer science and special engineering disciplines. This develops students' skills in systematic thinking, a comprehensive approach to problems, and the effective use of theoretical knowledge in practical situations. Cluster-based training teaches students to work in a team, exchange ideas, justify their positions, and find creative solutions.

LITERATURE REVIEW AND METHODOLOGY

Nowadays, digital learning environments are also actively entering the process of training engineers. When online platforms, virtual laboratories, and simulation programs are used in combination with cluster technology, the effectiveness of the educational process increases. This allows students to deeply assimilate knowledge visually, logically, and practically.

1. The essence and theoretical foundations of cluster technology. The word “cluster” is borrowed from the English language, and “cluster” means “group”, “collection”, “connection”, “system”. In the educational process, cluster technology is a pedagogical approach based on grouping, systematizing and visually representing educational material not separately, but in a logically interconnected manner. This technology helps students perceive knowledge as a holistic system, understand the internal connections between concepts, and deeply master the subject. The theoretical foundations of cluster technology are based on the ideas of constructive education, a systematic approach and activity-oriented pedagogy. According to this approach, the student acquires knowledge not in a ready state, but through research, analysis and generalization in the course of his activity. The cluster method supports this process, that is, it activates the student's independent thinking, analytical approach and creative search in his educational activities. The scientific and theoretical foundations of the educational cluster, its principles of continuity, coherence, consistency and other aspects, its innovative model and mechanisms for its implementation in practice are covered in the works of U.Alimov, A.Kh.Boymurodov, N.H.Kushiyeva [3, 4, 5].

The use of cluster technology in the educational process creates the following broad opportunities:

***Firstly,* systematization of knowledge.** Students systematically arrange the concepts given on the topic, isolate the main and secondary ideas, and determine their interrelationships. This helps not only to memorize information, but also to understand and assimilate its content.

***Secondly,* the development of logical thinking.** In the process of clustering, students identify cause-and-effect relationships, compare concepts, summarize, and draw conclusions. As a result, their analytical thinking, systematic approach, and ability to logically solve problems are formed.

***Thirdly,* analysis of problem situations.** Through the cluster method, students study complex situations by breaking them down into parts, analyzing the function of each element, and searching for optimal solutions. This creates the basis for future engineers to effectively solve real production problems.

***Fourth,* the formation of a creative approach.** Cluster technology allows students to think freely, offer new ideas and find alternative solutions. Working with visual models in the learning process enhances creativity and develops innovative thinking.

***Fifth,* increasing student activity.** In cluster-based classes, the student is not just a listener, but an active participant. He asks questions, participates in discussions, expresses his opinion and justifies his point of view. This increases the effectiveness of the learning process. In general, cluster technology transforms the student from a passive learner into an active, independent and creatively thinking subject in the educational process. In particular, in engineering education, the cluster method is of great importance in the systematic mastery of complex technological processes, the integration of theory and practice, and the formation of professional competencies.

2. Modern requirements for training engineers. Today, the rapid development of industry, production and technology places new qualitative requirements on the system of training engineers. A modern engineer must not only have sufficient theoretical knowledge in his profession, but also be able to independently solve complex problems encountered in practical activities, put forward innovative ideas and have the skills to work with modern technologies. Therefore, a competency-based approach is gaining priority in the process of training engineers.

A modern engineer must have the following key competencies:

Technical thinking and analytical thinking. An engineer must be able to deeply analyze technical systems, understand the essence of processes, and identify cause-and-effect relationships. Analytical thinking allows an engineer to break down complex issues into components and solve them systematically.

Ability to solve problem situations. Various technical, organizational, and technological problems arise in the production process. An engineer must be able to quickly and reasonably solve these problems, correctly assess the current situation, and choose the optimal solution. These skills are developed in students through practical training, project work, and cluster technology.

Innovative approach. A modern engineer must strive for innovation, be able to offer new ideas for improving technological processes, increasing efficiency, and saving resources. Innovative thinking makes an engineer a competitive specialist.

Teamwork skills. In today's production environment, engineers work not alone, but in a team. Therefore, a culture of communication, cooperation, exchange of ideas, the ability to justify one's point of view and respect for the opinions of others are important. Teamwork skills are effectively formed by involving students in group work on a cluster basis.

Effective use of information technologies. Digital technologies have become an integral part of engineering activities. An engineer must be able to use modern programs, modeling tools, automated systems and digital platforms. This speeds up the production process and increases its quality [6, 9]. Cluster technology plays an important role in the formation of the above-mentioned competencies. This technology combines theory and practice, activates students' independent thinking and brings them closer to real production conditions. As a result, future engineers are formed as mature specialists based on modern requirements.

3. Methodology of using cluster technology. Cluster technology unites subjects, each of which is engaged in separate activities, around a common goal, and at the same time, each subject acts in its own interest, proceeding from a common goal. The subjects of cluster technology support and control each other, each of which creates a spiritual and intellectual space for a separate cluster, expanding its social influence and significance. The innovative cluster of pedagogical education serves to organize classes based on the principles of natural connection, coherence, consistency, modernity, orientation, commonality of purpose, specificity of interests, and mutual control, which serves to conduct the educational process in a systematic, logical and interactive manner. This method allows students to deeply

assimilate knowledge, think independently, and apply it in practical activities [7]. The organization of classes on the basis of a cluster is carried out in several successive stages. [8].

RESULTS AND DISCUSSION

The first stage is the definition of the topic. The teacher defines the main goals and objectives of the lesson and presents the topic in an understandable form for students. The relevance of the topic, its importance in engineering activities are revealed. At this stage, it is important to attract students' attention to the topic.

The second stage is the definition of key concepts. Students identify key terms, ideas and concepts on the topic. In this process, their prior knowledge is activated, important and secondary information is separated. As a result, the general content of the topic is formed.

The third stage is the division of concepts into groups. The identified concepts are placed in certain systems according to their content. Students divide them into interrelated groups, determine the components of the topic. This helps to organize and systematize knowledge.

The fourth stage is to show the relationship. One of the most important aspects of cluster technology is to determine the relationship between concepts. Students show how each element relates to others, determine cause-and-effect relationships. Logical relationships between concepts are expressed through visual cluster schemes. This process develops students' systematic thinking and helps them understand the topic as a whole.

The fifth stage is to analyze. The topic is studied in depth based on the formed cluster. Students analyze, compare, summarize the information provided, and express their opinions on problem situations. At this stage, discussions, group work, and practical assignments are of great importance.

The sixth stage is to draw conclusions. At the end of the lesson, students summarize the acquired knowledge, identify the main ideas, and determine ways to apply them to practical activities. The teacher draws a general conclusion and evaluates the results. [10].

In general, the methodology of using cluster technology expands the student's thinking, helps to systematically assimilate knowledge, and increases the effectiveness of the educational process by combining theory and practice. In this statistical analysis, hypothesis H1 was chosen as the hypothesis indicating the effectiveness of student learning, and hypothesis H0, which contradicts it that is, indicating the absence of effectiveness in each conducted experimental work was selected. As hypothesis H0, i.e., there is no difference in the results obtained, and as hypothesis H1, i.e., there is a difference in the results obtained, we assume that it is effective.

A comparative analysis of the results of the conducted research shows that based on the initial test results, the number of students with low grades exceeds the number of students with high and medium grades; it can be assumed that the level of knowledge of the students at the beginning of the experiment is the same. In the results of the experimental assignment, the opposite was observed; specifically, the levels of improvement in the methodology for developing the professional competence of future engineering specialists developed for 1st and 2nd-year students differed. Proving the reliability of these data and the reliability and accuracy of the conclusions drawn was carried out using mathematical and statistical methods.

CONCLUSION

The use of cluster technologies in the process of improving the professional training of future engineers is one of the important directions of today's education system. This technology activates the educational process, helps to systematically assimilate knowledge, and turns students from passive listeners into active participants. Through cluster technology, students combine theoretical knowledge with practical activities, develop skills

in analyzing problem situations, logical and creative thinking, teamwork, and independent decision-making. This serves to comprehensively develop the professional competence of future engineers. Also, the introduction of cluster technology strengthens the relationship between education and production, increases economic efficiency, and serves to train competitive personnel in the labor market. In this process, students' social activity, responsibility, and professional maturity are formed.

In general, the systematic and targeted use of cluster technologies will bring the quality of training future engineers to a new level. As a result, creative, innovative, and competitive engineering specialists who can think in accordance with modern requirements are formed in higher educational institutions.

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