

Improved Model for Developing Professional Competencies of Future Engineering-Energy Specialists Based on Software-Based Educational Tools

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Abstract: The article examines an improved model for developing the professional competencies of future power engineers based on software-based educational tools. The necessity of modernizing the system of specialist training is substantiated, taking into account current trends in the development of the energy sector, including digitalization, automation, and the integration of renewable energy sources. Methodological approaches, principles, methods, and tools for the formation of professional competencies are presented, as well as the role of software-based learning tools in enhancing the effectiveness of the educational process. Special attention is paid to problem-based, project-based, and modular learning, which contribute to the development of practical skills, innovative thinking, and students' independent activity. The developed model is aimed at training competitive specialists capable of effectively solving modern challenges in the energy sector.

Keywords: Power engineers, professional competencies, software-based educational tools, digitalization of education, innovative technologies, problem-based learning, project-based learning, modular learning, energy sector, renewable energy sources, virtual laboratories, e-learning.

Introduction: Today, the energy sector is developing rapidly and is becoming one of the main drivers of the global economy. The continuously increasing demand for energy resources, the necessity of extensive use of renewable energy sources, and the automation and digitalization of production processes are significantly increasing the modern requirements for the professional competence of engineering and energy specialists. In particular, the development of electric power engineering, thermal power engineering, hydropower, nuclear energy, and renewable energy systems requires specialists not only to possess fundamental theoretical knowledge but also practical skills, a deep understanding of technologies, and innovative thinking.

In our republic, the energy system is also undergoing a stage of fundamental reforms. Strategic programs are being implemented to introduce renewable energy sources, widely apply energy-saving technologies, modernize power grids, automate production, and expand digital control systems. In particular, within the framework of the green energy concept, the construction of solar and wind power plants, modernization of energy infrastructure, and the transition of power grid systems to automated intelligent control systems, namely smart grid technologies, are further increasing the need for new-generation competencies among future engineering and energy specialists.

The system of training engineering and energy specialists in higher educational institutions must be continuously updated in accordance with modern requirements. Although the current educational standards have many positive aspects, they still require constant improvement, development of digital

competencies, practical training, project-based approaches, and innovative thinking. Students should not be limited only to theoretical knowledge; the following competencies should also be developed (see Figure 1).

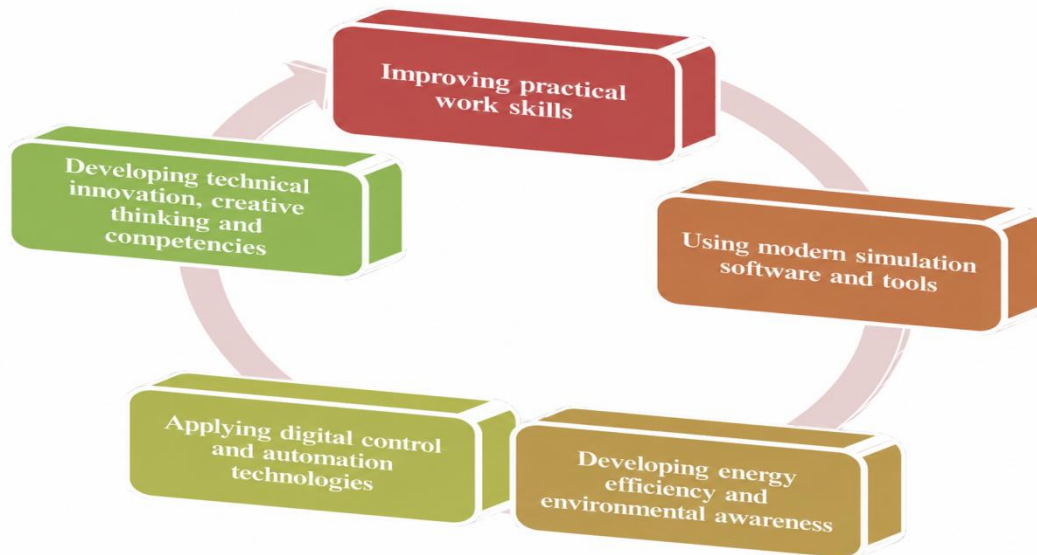


Figure 1. Stages of Developing Engineering Competencies of Future Engineer-Energy Specialists

Global changes in the energy sector — including the introduction of automatically controlled smart energy systems, green energy, energy storage systems, electronic management, and energy security concepts into practice — require the implementation of new

pedagogical models in the educational process. Such a model creates a foundation for students to develop independent thinking, problem-solving abilities, the capability to analyze and synthesize modern technologies, and to propose innovative ideas within the field.

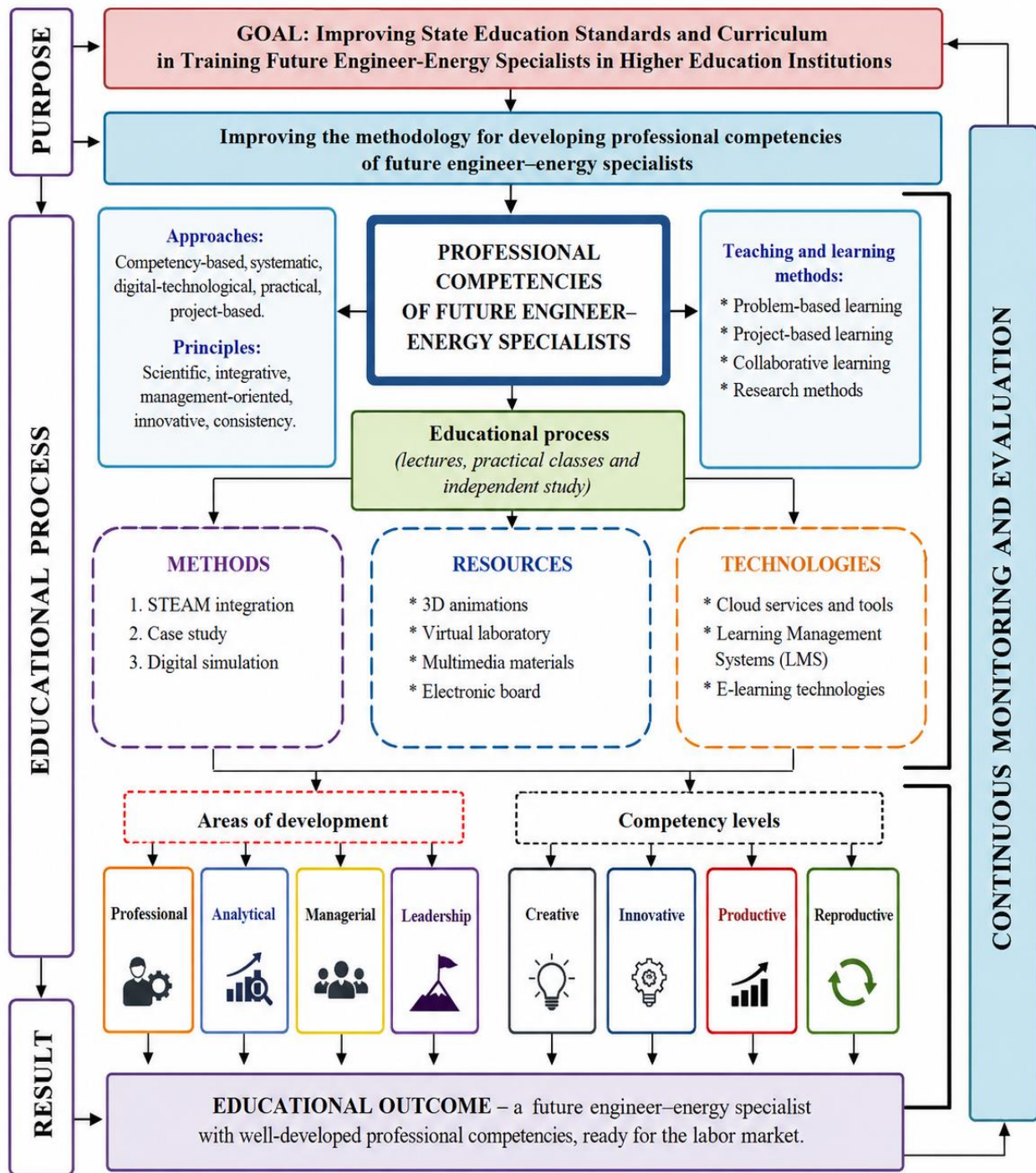


Figure 2. Improved Model for Developing Professional Competencies of Future Engineer-Energy Specialists

Improving the model for developing the professional competencies of future engineer-energy specialists is strategically important not only for the quality of education, but also for solving the country's energy-related problems, increasing industrial competitiveness, and ensuring economic stability. Through this model, the scientific and methodological foundations for training future engineer-energy specialists in accordance with modern requirements, the set of competencies, and the development model were improved (see Figure 2).

Social demand: Refers to the preparation of future engineer-energy specialists who meet the requirements of qualification standards and educational sector standards.

Purpose: The purpose is to improve the methodology for developing the professional competencies of future engineer-energy specialists by developing software-based educational tools and introducing them into the innovative educational process. One of the most effective ways of development is teaching subjects on

the basis of modern innovative requirements in order to train students as mature and competitive specialists.

In the improved model, the purpose of enhancing the methodology for preparing students for innovative professional activity through software-based educational tools is to study the didactic and organizational-methodological features of using educational software in shaping students of energy engineering programs into creatively thinking

specialists based on didactic approaches and innovative principles.

Approaches: The process of improving the methodology for developing the professional competencies of future engineer-energy specialists is considered a complex and multifactorial pedagogical system. This system is implemented on the basis of the following mutually integrated approaches:

The educational process in higher education institutions ensures the formation of competence orientation and the development of professional competencies as a result. The competencies of theoretical knowledge, practical skills, independent decision-making, and innovative thinking are formed as professional potential.

All components of the teaching and learning process (goal, tasks, methods, resources, assessment) are implemented in an interconnected and consecutive manner. Professional training is not fragmentary, but designed as an integrated system.

Digital and technological integration is used to modernize the educational process on the basis of modern energy sector requirements, and to introduce simulation, virtual laboratories, and innovative technologies into practice, thereby improving the educational process. With the help of digital educational tools, students are brought closer to real production conditions.

The leading role in preparing future engineer-energy specialists in analytical and design systems is played by modern theoretical knowledge, analytical tools and software. Students develop engineering thinking by solving real professional problems.

Objective and measurable professional competency indicators are used as the basis for assessment. The assessment process is organized as a transparent, measurable, and development-oriented system that reflects the dynamics of progress.

Principles: The process of improving the methodology for developing the professional competencies of future

engineer-energy specialists is based on the following interrelated principles (see Figure 3).



Figure 3. Principles for improving the methodology of developing professional competencies of future engineering and energy personnel.

Visualization – In the educational process, theoretical knowledge is reinforced through visual, practical, and technical tools. Electrical schemes, laboratory work, modeling, and simulations help students clearly understand complex energy processes based on concrete visualization. This develops students' technical thinking.

Integrativity – In the training of future engineering-energy personnel, professional preparation is organized on the basis of interdisciplinary connections. That is, energy, automation, information technologies, economics, and ecology are integrated. As a result, students develop complex and systemic thinking.

Manageability – The educational process is organized as a pedagogical system that is planned, monitored, and its effectiveness analyzed. The continuity between objectives–content–methods–assessment is ensured, and the formation of competencies is controlled.

Adaptability – The methodology is regularly updated based on modern energy technologies, digital tools, and labor market requirements. In addition, students' individual abilities and learning pace are taken into account.

Software-based educational and methodological support: In the formation of future engineering-energy specialists, new information can be obtained from software-based educational tools developed for

specialized subjects such as “Theoretical Electrical Engineering” and “Industrial Power Supply Systems.” These tools enable full classroom coverage of students during lessons. They can also be used in full-time, part-time, and distance learning. One of the main advantages of using such tools in distance learning is that students can access them anytime and anywhere, regardless of location.

Educational process: The learning process is based on national and international standards such as O'zDSt and GOST, regulatory guidelines on energy safety, and technical regulations as the main normative base. In improving the methodology for developing professional competencies of future engineering-energy personnel, electronic textbooks, teaching aids, and software-based educational tools strengthen theoretical preparation. Practical training is focused on mastering real energy processes through visual tools such as electrical circuits, energy flow diagrams, laboratory stands, and simulation systems.

Teaching methods: STEAM-integrated learning method, Case-study method, and Digital Simulation method.

The STEAM-integrated learning method is closely related to production needs and the content of specialized subjects in the training of future engineering-energy specialists. Through this method, students are able to combine science, technology,

engineering, mathematics, and creativity. Considering individual abilities, interests, and aspirations, students are given various project and practical tasks. For example, designing a solar power plant model, developing energy-efficient devices, or creating automated electrical systems helps improve their professional training.

The STEAM-integrated learning method develops students' creative thinking, strengthens interdisciplinary integration, and combines theoretical knowledge with practical activity. As a result, future engineering-energy specialists develop innovative thinking, technical reasoning, and independent decision-making competencies.

The Case-study method contributes to preparing students of energy-related fields for professional activity by applying real industrial problems to the learning process. In this method, students gain professional experience by analyzing practical issues occurring in energy enterprises. For example, case tasks may include power system failures, transformer overloads, energy losses, or malfunctions in electrical supply systems. Students analyze these situations, identify causes, and develop optimal solutions.

The Case-study method develops independent thinking, rapid decision-making, and effective action in problem situations. As a result, students develop competencies

in diagnostics, analytical thinking, and professional responsibility.

The Digital Simulation method in teaching energy-related subjects is one of the most important modern educational approaches. Using this method, students are able to model and control energy processes in a virtual environment. Software such as MATLAB, AutoCAD Electrical, Proteus, Multisim, and others is used to simulate electrical networks, transformers, renewable energy sources, and automated systems.

The Digital Simulation method develops students' ability to use information technologies effectively, allows them to study complex technical processes in a safe environment, and enhances their digital competencies. As a result, future engineering-energy specialists gain innovative potential and adaptability to modern industry.

The use of the above-mentioned methods plays a key role in strengthening theoretical knowledge, developing practical skills, and forming innovative and digital competencies of future engineering-energy specialists. These methods increase the effectiveness of the educational process and expand opportunities for training competitive professionals. As a result, the following competencies are developed in future engineering-energy specialists (see Figure 4).

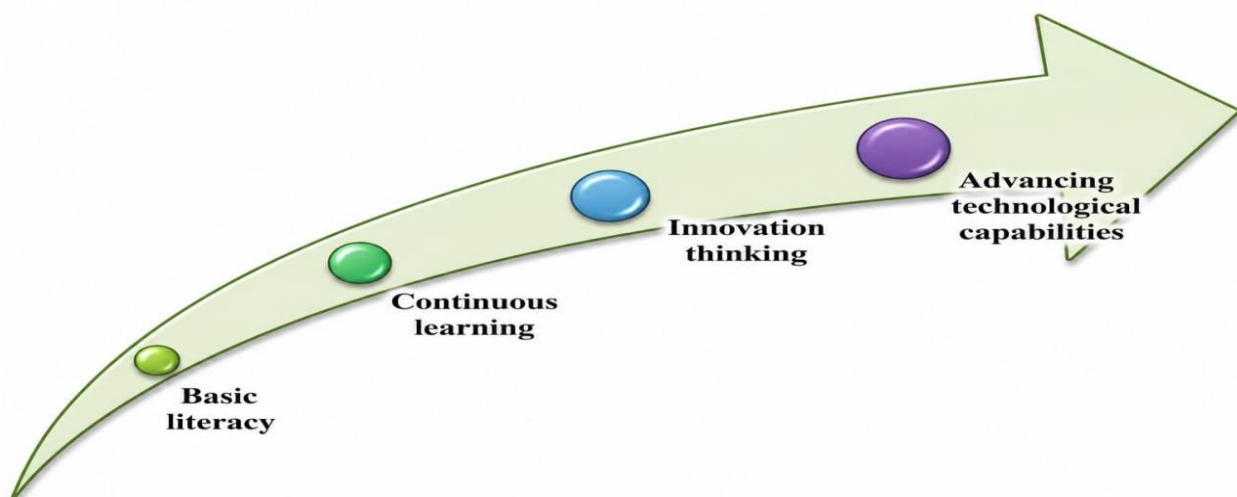


Figure 4. Development of Professional Competence in Future Engineering-Energy Specialists

Tools for Developing Professional Competence of Future Engineering-Energy Specialists.

In teaching subjects related to the energy engineering field, in order to ensure interdisciplinary continuity,

educational tools such as the textbook "Theoretical Electrical Engineering" and the electronic textbook "Electric Power Supply of Industrial Enterprises" were developed and implemented in a programmed format to enhance the engineering competence of future

energy specialists. In the context of an information-educational environment, educational tools that support the creative training of future engineering-energy specialists in their professional activity include electronic textbooks, teaching aids, 3D animations, virtual laboratories, multimedia materials, electronic boards, video projectors, electronic information resource centers, and reality-based teaching tools. These play a key role in developing the professional competencies of future engineering-energy specialists.

In the training of future engineering-energy specialists, innovative educational technologies were integrated into the development of the textbook “Theoretical Electrical Engineering” and the electronic textbook “Electric Power Supply of Industrial Enterprises.” These materials were approved by the Ministry of Higher and Secondary Specialized Education of the Republic of Uzbekistan and the Intellectual Property Agency, and they are actively used in the teaching and learning process. Through these teaching tools, theoretical, practical, and laboratory classes with students cover the fundamental laws of electrical and magnetic phenomena in the subject of Theoretical Electrical Engineering, the operating principles of electrical circuits, electromagnetic processes, and the theoretical foundations of energy conversion processes. In addition, relationships between electrical quantities (current, voltage, power, resistance), the analysis of DC and AC circuits, the properties of electric and magnetic fields, and their practical applications are scientifically explained. This course helps students understand the operating principles of electrical devices, analyze them, and master calculation methods.

Opportunities for improving the methodology of developing professional competencies of future engineering-energy specialists:

Updating the content of curricula and programs and modernizing teaching-methodological support are important strategic directions. Effective use of these opportunities elevates the quality of education to a new level. Improving curricula ensures that the educational process corresponds to technological changes in the modern energy sector and serves as a foundation for developing professional competencies of engineering-energy specialists. Revising course content, optimizing the balance between theory and practice, and widely introducing digital technologies and renewable energy sources into curricula enhance the practical orientation of professional training. This enables students to acquire competencies aligned with labor market demands.

Improving the teaching-methodological support of the educational process is an important factor in increasing learning effectiveness. By applying modern pedagogical and digital tools, using interactive methods, and introducing virtual laboratories and simulation programs, the level of mastering complex energy processes significantly increases. In this regard, developing competency-based assessment criteria and implementing an objective evaluation system ensures transparency and reliability of educational outcomes.

When the above-mentioned opportunities for training future engineering-energy specialists are applied in an integrated manner, the following results can be achieved (see Figure 5).

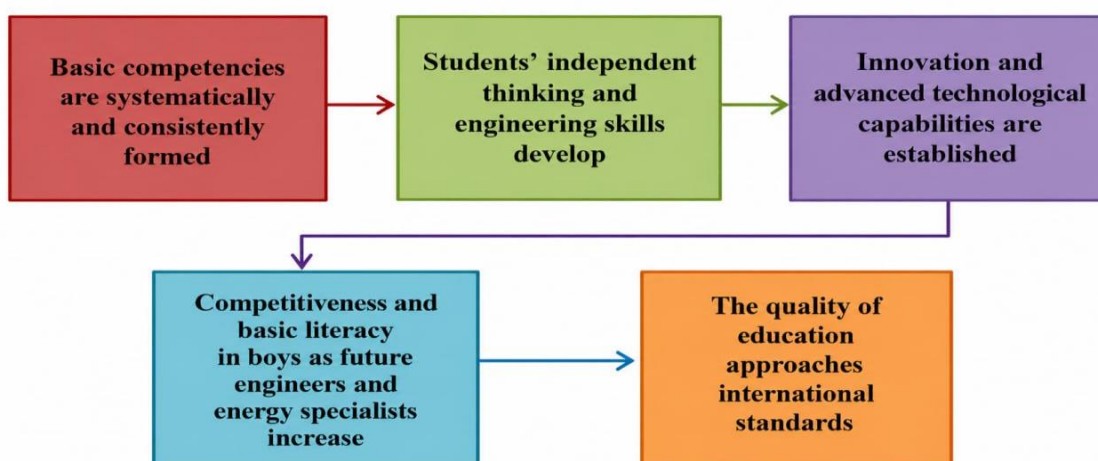


Figure 5. Results of Developing Professional Competencies of Future Engineering-Energy Specialists

Updating the content of curricula and study programs in accordance with modern requirements, as well as improving teaching and methodological support by providing resources that meet current production demands and play an important role in solving practical problems, strengthens the methodological and practical foundations of the process of training future engineering-energy specialists. This, in turn, contributes

to the formation of highly qualified and innovative-thinking professionals aligned with modern development trends in the energy sector.

The result-oriented component includes assessment criteria (Initial, Basic, Stable, Professional) and levels of training (Reproductive, Productive, Exploratory, Creative) (see Table 1.1).

Table 1.1
Students' Levels of Preparedness

No	Level of Formation of Concepts Related to Future Engineering-Energy Specialists	Students' Interest in the Electrical Energy Profession	Teacher's Responsibilities
1	Reproductive (Low) Level	Shows no interest in electrical energy concepts, demonstrates a passive attitude toward the subject, and is unable to provide clear answers to the teacher's questions.	Identifying the causes of low interest, organizing individual sessions, and developing concepts through visual aids, interactive methods, and simple examples.
2	Productive (Medium) Level	Has a partial understanding of basic energy-related concepts, but experiences difficulties in fully explaining them and applying them in practical tasks.	Reinforcing knowledge through additional exercises, simple practical tasks, illustrative examples, and step-by-step explanations.
3	Exploratory (Good) Level	Has a good understanding of energy-related concepts, answers most questions correctly, and demonstrates a sufficient level of independence in completing practical tasks.	Deepening knowledge through more complex problems, modeling tasks, and project-based assignments.
4	Exploratory (Good) Level	Has a deep understanding of energy-related concepts, can independently apply them in practical situations, analyze them, and justify engineering decisions.	Encouraging research-based tasks, project work, development of innovative ideas, and independent inquiry.

Assessment Criteria: In determining the level of development of professional competencies of future engineering-energy specialists, assessment criteria play an important role. These criteria make it possible to systematically evaluate students' theoretical knowledge, practical skills, and readiness for professional activity. Based on the assessment results, the stages of students' professional competence formation are identified through the following levels:

At the Initial level, the student's knowledge and skills related to the energy field are insufficiently formed. They struggle to connect theoretical concepts with practical activities, and their ability to work independently in performing professional tasks is poorly developed. This level indicates the need for additional pedagogical intervention and methodological support in developing professional competencies.

At the Basic level, the student has acquired fundamental theoretical knowledge in the energy field, but may face difficulties in applying it in practical situations. In performing practical tasks, they often rely

on the teacher or methodological guidelines. This level represents the initial stage of professional competence formation.

At the Stable level, the student has sufficiently mastered theoretical knowledge and practical skills related to the energy field. They are able to work independently in tasks related to energy systems, although they may still require additional guidance when solving complex problems. This level indicates a stable stage in the development of professional competencies.

At the Professional level, the student is able to deeply analyze energy systems, equipment, and technological processes, and independently perform modeling and calculations using modern software tools. They are also capable of making optimal engineering decisions in problem situations and proposing innovative solutions aimed at improving energy efficiency. This level reflects full professional maturity and readiness for industrial practice of future engineering-energy specialists.

Competency Levels

1. Reproductive level In the learning process, the student reproduces the basic natural sciences related to the energy field and repeats the information provided based on the given examples. In this stage, he performs simple practical tasks given by the teacher, but is not yet able to independently analyze, critically evaluate, or generate new solutions.

2. Productive level In the learning process, the student applies the acquired knowledge in practical activities. He understands energy processes and works to solve ordinary technical problems independently. At this stage, the ability to make correct decisions begins to form in applying knowledge and skills in both familiar and unfamiliar situations.

3. Analytical level In the learning process, the student analyzes problems in the energy field, compares different solution options, and draws independent conclusions. He benefits from modeling, calculation, and experiments to discover new information as well as elements of scientific research.

4. Creative level In the learning process, the student deeply analyzes energy systems and processes, offers innovation ideas, and designs new engineering solutions. He develops a sense of responsibility, works to increase energy efficiency, and has the ability to solve complex problems based on original thinking.

In the development of future engineering-energy specialists, the direct guidance of the teacher and methodological instructions play an important role in the teaching process of specialized subjects. In this process, students recall previously acquired theoretical knowledge, systematize it, and enrich it with new knowledge. In particular, in teaching energy-related subjects, it is of great importance for students to integrate theoretical knowledge with practical problems. Strengthening theoretical knowledge related to electrical power systems, energy conversion processes, and the operating principles of technical devices through practical tasks enables students to gain a deeper understanding of the essence of the studied processes.

CONCLUSION

In the process of developing professional competencies of future engineering-energy specialists, the use of modern software-based educational tools alongside traditional educational literature is of special importance. In particular, electronic textbooks, electronic teaching aids, virtual laboratory stands, 3D animations, and computer-based knowledge assessment systems ensure active involvement of students in the learning process. The above-mentioned tools provide an opportunity to study complex energy processes in a visual and interactive form, thereby increasing students' motivation. As a result, their theoretical knowledge is strengthened, and their practical skills and competencies are further improved, ensuring the preparation of highly qualified future engineering-energy specialists.

In the modern educational process, the use of new pedagogical technologies and methods not only enriches the content of education but also requires the renewal of teaching forms, methods, and tools. The rapid development of information technologies has brought new opportunities into the educational process. In particular, the use of software-based educational tools is considered one of the most effective means of developing students' independent thinking, forming their professional competencies in the field of energy, and objectively assessing their knowledge. Therefore, the effective use of software-based educational tools in the training of future engineering-energy specialists serves as an important

methodological factor that improves the quality and effectiveness of education.

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