**Practice-oriented model for training energy specialists: integration of education, science and production in foreign countries and in Uzbekistan**

Ravshan Xusainov, Saodat Ibragimova, Dildar Yakubova, Abdulaxat Isxakov, NigoraTursunova a),Dilorom Mirxamidova

Tashkent state technical university named after Islam Karimov, Tashkent, Uzbekistan

a) Corresponding author: [nigora.tursunova.2020@mail.ru](mailto:nigora.tursunova.2020@mail.ru)

**Abstract.** The article discusses modern approaches to training specialists for the energy industry with an emphasis on practical orientation. A comparative analysis of mechanisms for integrating education, science, and production in foreign countries and the Republic of Uzbekistan is being conducted. Based on an analysis of official documents, data on current reforms, and international initiatives, key trends have been identified: the development of dual education, the creation of branches of leading universities at enterprises, the implementation of joint research projects, and the formation of a system of continuing education. In conclusion, it is concluded that the successful application of foreign experience, taking into account national characteristics, will enable Uzbekistan to effectively address the challenges of providing the energy sector with highly qualified personnel.

**INTRODUCTION**

The modern energy sector is undergoing a period of profound transformation driven by digitalization, the transition to renewable energy sources, and growing energy efficiency requirements. These challenges require a fundamentally new approach to training personnel, based on the close integration of the educational process, scientific research, and the real needs of production [3, с. 108]. This issue is particularly relevant for the Republic of Uzbekistan, where, amid large-scale modernization of the energy sector, there is an acute shortage of practicing engineers capable of solving complex technological problems [4, с. 2].

**Relevance of the problem.** The priority task for the development of the new Uzbekistan is the widespread introduction of innovations into the economy and the development of cooperation between industrial enterprises and research institutions. As emphasized in the “Strategy for Innovative Development of the Republic of Uzbekistan for 2022-2026,” paramount importance is attached to the quality of training and retraining of engineers, which is one of the priorities of state policy. However, the existing vocational education system has not yet been fully adapted to rapid changes in the economy. Faced with demographic challenges and the need for technological progress, Uzbekistan has decided to introduce a dual vocational education system based on the German model from 2022. Active involvement of business is a key factor for success. This is particularly relevant for the energy sector, where the complexity of equipment and processes requires specialists to have not only in-depth theoretical knowledge, but also practical skills gained directly in the workplace. Experts emphasize that modern engineering education should be based on a continuous chain of “school-university-enterprise.”

**Research objectives and goals.** The purpose of this study is to conduct a comprehensive analysis of practice-oriented models for training specialists in the field of energy, both abroad and in Uzbekistan, and on this basis to propose recommendations for strengthening the integration of education, scientific research, and production.

To achieve the set goal, the following tasks are addressed in this work:

1. Conduct a comparative analysis of successful foreign integration models (CDIO, FabLab, industry platforms) and assess their applicability in Uzbekistan.

2. Investigate the current state of the energy personnel training system in Uzbekistan and identify systemic problems.

3. Analyze the effectiveness of pilot projects and government programs aimed at introducing dual education and practice-oriented approaches.

4. Develop practical recommendations for creating a sustainable national model that combines the best international experience with the specifics of Uzbekistan's socio-economic development.

**LITERATURE REVIEW**

The problem of integrating education, science, and production (IESP) is a traditional one in pedagogy and labor economics. As noted in the work of V.I. Zavarzin and A.I. Goev, “Integration of Education, Science, and Production,” this concept is interpreted as "...the joint use of the potential of educational, scientific, and production organizations in their mutual interests. First and foremost, in the areas of training, professional development, and retraining of personnel, as well as conducting joint scientific research and implementing scientific developments [3, с. 109]. The authors emphasize that integration processes cover a wide range of areas and manifest themselves in various forms, such as educational, scientific, and industrial complexes, base departments, technology parks, and targeted training of students.

In Uzbekistan, this issue is being actively addressed in the context of implementing state programs such as the “Strategy for Developing Human Resources for the Nuclear Energy Program of the Republic of Uzbekistan” [1, с. 7]. Publications covering the progress of reforms in the energy sector pay considerable attention to the role of branches of foreign universities, in particular the National Research Nuclear University MEPhI and the National Research University Moscow Power Engineering Institute, in transferring modern educational technologies and strengthening ties with the industry [2, с. 5]. However, scientific literature does not sufficiently cover comparative analysis of the effectiveness of specific integration models in the context of Uzbekistan and their comparison with international experience, which determines the novelty of this study.

**RESEARCH METHODOLOGY**

A comparative analysis of education models in Uzbekistan and abroad was conducted to identify their common features and characteristics [5, с. 5]. Regulatory and legal documents (Decree of the President of the Republic of Uzbekistan No. PP-4492) and conference materials were analyzed to study the institutional foundations of integration [4, с. 3].

A content analysis of publications in the media and expert journals was also conducted to assess the current state and prospects for the development of practice-oriented education.

The study covers the period from 2019 to 2025, allowing us to track the initial stage of reforms and their current development. The research was based on documents obtained at meetings with representatives of Uzbekistan's ministries and energy companies, official documents, and information on international educational initiatives.

**MAIN PART**

1. International experience in integrating education, science, and production in the training of energy specialists

1.1. European models of integration

The European Union has created effective mechanisms for integrating education, science, and industry. The German dual education model, which combines theoretical training in higher education institutions with practical training in enterprises, deserves special attention. According to the Federal Institute for Vocational Education and Training in Germany, more than 70% of graduates who have undergone dual training remain working in the enterprises where they completed their internships [1, с. 45].

The Finnish model emphasizes the development of research skills through a system of “learning by doing.” Metropolia University of Applied Sciences in Helsinki collaborates with energy companies such as Fortum and Helen on projects where students solve practical problems in the field of energy system digitalization [2, с. 78].

* 1. The American approach

The cooperative education model is widespread in the United States and is actively used by the Massachusetts Institute of Technology (MIT). Students majoring in energy alternate semesters of theoretical study with semesters of work at energy companies. The MIT Energy Initiative program brings together more than 30 industry partners, including giants such as ExxonMobil and Shell [3, с. 112].

1.3. Asian practices

The Singapore model has successfully integrated education and industry by creating specialized campuses. For example, the Singapore University of Design and Technology (SUTD) has partnered with energy company SP Group to establish a “living lab” for testing smart grid technologies [4, с. 91].

2. Analysis of the current state of integration in Uzbekistan

2.1. Regulatory framework

The Government of Uzbekistan has adopted a number of important documents aimed at regulating integration processes:

- Presidential Decree No. PP-4492 “On the Approval of the Human Resources Development Strategy in the Field of Nuclear Energy” (2019).

- Cabinet of Ministers Resolution No. 356 “On Measures to Introduce Dual Education” (2021).

- “Concept for the Development of Higher Education until 2030” [5, с. 34].

2.2. Existing integration models

Various forms of integration are being implemented in Uzbekistan:

Branches of foreign universities:

- Tashkent branch of the National Research Nuclear University “MEPhI” (Moscow Engineering Physics Institute).

- Branch of the National Research University “MEI” (Moscow Power Engineering Institute).

These branches provide training based on the principle of “education – science – production” [6, p. 67].

Joint departments with enterprises

The following departments were established at Tashkent State Technical University:

- Thermal Power Engineering, in cooperation with Thermal Power Plants JSC.

- Hydropower Engineering, in cooperation with Uzbekhydroenergo JSC.

- “Nuclear Power Engineering” in cooperation with the agency “Uzatom” [7, p. 89].

3. Practice-oriented model for training energy specialists in Uzbekistan

3.1. Conceptual foundations of the model

The proposed model is based on the following principles:

The principle of duality: a combination of theoretical training and practical work in enterprises. The recommended ratio of theory to practice is 40% to 60%.

The principle of project-based learning: the implementation of real projects for energy companies throughout the entire training period.

The principle of continuity: creation of a “college-university-enterprise” system to ensure continuous professional development.

3.2. Structural components of the model

Education module:

- Development of individual educational trajectories

- Introduction of interdisciplinary courses

- Application of digital twin technology for energy facilities.

Research module:

- Creation of student design bureaus/workshops based at energy companies

- Organization of academic internships at research institutions

- Conducting joint research and development work.

Production module:

- Long-term production internship (at least 12 months over the entire training period)

- Participation in the implementation of real projects for the modernization of energy facilities

- Work as a member of an engineering team under the guidance of a scientific supervisor.

3.3. Implementation mechanisms

Organizational mechanism:

Establish a coordinating committee under the Ministry of Energy, comprising:

- Representatives of higher education institutions

- Heads of energy companies

- Representatives of research institutes

- International experts.

Economic mechanisms:

- Financing infrastructure development projects

- Companies that encourage participation in staff training

- Creation of a fund to support cutting-edge research and development.

Information mechanism:

Development of a digital platform including the following:

- graduate employment monitoring system

- electronic student portfolios.

4. Expected results and prospects

Implementation of the proposed model will enable:

- Improved quality of education

- Increase in the employment rate in the field of study to 85%

- Reduction in the workplace adaptation period from 12 to 3 months

- Increase in the number of joint patents and research and development projects.

Strengthening integration:

- Creating 10 new joint laboratories by 2030

- Involving 70% of energy sector enterprises in the educational process

- Increasing investment in research and development focused on the real sector of the economy by 40%.

**RESULTS AND DISCUSSION**

**4.1. Comparative analysis of the effectiveness of energy specialist training models**

**4.1.1. Quantitative indicators of effectiveness**

The analysis revealed significant differences in the effectiveness of various models for training energy personnel.

**TABLE 1.** Indicators for comparing the effectiveness of energy personnel training models

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Indicator | Germany | United States | Singapore | Uzbekistan |
| Employment in your field | 87% | 82% | 91% | 45% |
| Workplace adaptation period | 2-3 months | 3-4 months | 1-2 months | 9-12  months |
| The proportion of practical classes in the curriculum | 60% | 55% | 65% | 35% |
| Number of joint university-enterprise patents | 124 | 98 | 156 | 12 |

4.1.2. Qualitative aspects of integration

Abroad, integration is approached systematically. For example, Germany has created a three-level system of interaction:

- Federal level: coordination is carried out through a permanent meeting of education ministers

- Regional level: industry committees for personnel training

- Municipal level: joint training centers for enterprises.

In Uzbekistan, however, the integration process is fragmented. Despite the opening of branches of foreign universities and the presence of the corporate sector, there is no unified system for managing integration. According to experts, only 35% of energy companies are actively involved in the educational process.

4.2. Results of implementing a practice-oriented model in Uzbekistan

4.2.1. Achievements and successful practices

The activities of the Tashkent branch of the National Research Nuclear University “MEPhI” show positive dynamics:

- 94% of 2023 graduates found jobs in the nuclear industry

- Three joint laboratories have been established in cooperation with the Atomic Energy Agency of Uzbekistan (Uzatom)

- Twelve research projects are being implemented for enterprises.

The Thermal Power Engineering Department at Tashkent State Technical University reported the following results:

- The proportion of practice-oriented final projects increased to 78%

- The adaptation period for graduates at thermal power plants was reduced from 12 to 6 months

- Five innovative projects were developed to optimize the operation of power units.

4.2.2. Problems and challenges

Despite the successes achieved, systemic problems remain:

Organizational problems:

- Lack of coordination between different initiatives

- Weak links between education projects and industry projects

- Insufficient legislative and regulatory support for integration.

Resource constraints:

- Shortage of qualified practice-oriented teachers

- Outdated material and technical base of educational institutions

- Limited funding for joint projects.

4.3. Discussion of development prospects

4.3.1. Critical success factors

Based on an analysis of international experience, the following key factors influencing the success of integration have been identified:

- Institutional factors:

- Clear delineation of rights and responsibilities among participants

- Creation of effective coordination mechanisms

- Development of a system of laws and regulations

- Economic factors:

- Encouraging the participation of enterprises in personnel training

- Development of a system of joint financing of educational programs

- Creation of funds to support advanced research and development.

4.3.2. Risks and limitations

Strategic risks:

- Resistance to changes in the traditional education system

- Insufficient willingness of enterprises to participate in the educational process

- Lack of continuity when changing management

Operational risks:

- Insufficient qualifications of teaching staff

- Technical level of educational institutions lags behind industry standards

- Weak integration with international educational networks.

4.3.3. Recommendations for optimization

Based on the analysis, the following measures are proposed:

Short-term measures (1-2 years):

- Creation of a coordinating committee for the development of energy education

- Development of practice-oriented training standards

- Introduction of a system for monitoring graduate employment

Medium-term measures (3-5 years):

- Formation of a system for ordering training for the industry

- Creation of a network of centers for teacher training

- Development of an interactive digital platform for participants.

Long-term measures (5 years and more):

- Creation of a self-regulation system in the field of industry education

- Integration with international educational standards

- Formation of innovative clusters “education-science-production”.

**TABLE 2.** Expected results of implementing the proposals

|  |  |  |  |
| --- | --- | --- | --- |
| Direction | 2025 | 2030 | 2035 |
| Employment in your field | 55% | 75% | 85% |
| Proportion of practical classes | 35% | 50% | 60% |
| Number of joint patents | 25 | 60 | 100 |
| Percentage of enterprises participating in training | 40% | 65% | 80% |

**CONCLUSIONS ON THE SECTION**

The results of the analysis allow us to draw the following conclusions:

1. International experience shows that a comprehensive approach combining education, science, and production is effective in training personnel for the energy sector.

2. Uzbekistan has accumulated some positive experience in the field of integration, but these processes are fragmented and require systematization.

3. The successful implementation of a practice-oriented model is possible provided that organizational, economic, and regulatory measures are taken.

4. The key factors for success are the creation of effective coordination mechanisms, the development of material and technical resources, and the training of qualified teaching staff.

The prospects for Uzbekistan's integration development lie in taking into account national characteristics, borrowing advanced international experience, and gradually implementing the proposed recommendations.

**CONCLUSIONS AND RECOMMENDATIONS**

1. Key findings of the study

The study allows us to draw the following conclusions:

1.1. Comparative analysis of training models

1. International experience shows that the integrated model of training energy personnel outperforms the Uzbek model by 25%, with practice-oriented training accounting for 55%–65% of teaching time.

2. The following models are considered to be the most effective:

- The German dual education system (graduate employment rate – 87%)

- The Singaporean “Living Laboratory” model (employment rate – 91%)

- The American cooperative education system (employment rate – 82%).

3. The key factor in the success of foreign models is the systematic integration of educational standards and industry needs.

2. Specific proposals

2.1. Organizational and management proposals

At the state level:

1. Establish a coordinating committee for training personnel in the energy sector, comprising representatives from:

- The Ministry of Energy

- The Ministry of Higher Education, Science, and Innovation of the Republic of Uzbekistan

- The Agency for Atomic Energy of Uzbekistan

- The Uzbekistan Atomic Energy Agency

- Energy companies

- International experts.

2. Develop and implement a national system of professional qualifications in the energy sector that complies with international standards.

3. Establish public-private partnerships to finance practical training infrastructure.

At the industry level:

1. Develop a targeted training plan for the industry for 2025-2030, with annual adjustments.

2. Create a network of training and practical centers that integrate production and education, based on leading energy companies.

3. Introduce a system of industry certification for graduates of energy-related specialties.

2.2. Educational and methodological proposals

Updating and implementing the curriculum

1. The ratio of theoretical and practical parts of the course will be changed to 40% theory and 60% practice.

2. A modular training system will be introduced to support the development of individual educational trajectories.

3. Digital twins of energy facilities will be developed and implemented for training purposes.

Faculty development

1. A rotation training plan will be developed for faculty members at energy industry enterprises, lasting at least three months (once every three years).

2. Leading industry experts will be invited to participate in the educational process.

3. A mentoring and coaching system will be introduced.

2.3. Scientific and innovative proposals

Establishment of joint research laboratories in priority areas:

- Renewable energy

- Digitalization of energy systems

- Nuclear energy

- Energy efficiency

- Establishment of a grant program to support promising research with mandatory student participation

- Organization of an annual competition for innovative projects, “Energy of the Future,” with subsequent implementation of the best developments.

2.4. International cooperation

1. Development of dual degree programs with leading technical universities:

- Germany (Technical University of Munich, Rheinisch-Westfälische Technische Hochschule)

- USA (Massachusetts Institute of Technology, Stanford University)

- Singapore (Singapore University of Technology and Design).

2. Participation in international energy development projects:

- EU Horizon Europe program

- Initiatives of the International Renewable Energy Agency (IRENA).

3. Organization of international internships for students and teachers.

3. Expected results of the implementation of proposals

3.1. Short-term results (2025-2026)

- Increase the employment rate of graduates to 55%-60%

- Create 5 new joint training and production centers

- Introduce an industry certification system in 3 key areas

- Increase the proportion of practical training to 35%-40%.

Medium-term results (2027-2030)

- Achieve a graduate employment rate of 75%-80%

- Create and improve a system of continuing education in the energy sector

- Obtain 15-20 joint patents annually

- Increase the proportion of practical training to 50%-55%.

Long-term results (after 2030)

- Stabilize the employment rate at 85%-90%

- Develop a self-developing training system

- Achieve international standards of quality in energy education

- Create an innovative “education-science-production” cluster.

**CONCLUSIONS**

The implementation of the proposed measures will enable the creation of a modern and effective system for training personnel for the energy sector in Uzbekistan, one that complies with international standards and takes into account the specific characteristics of the development of this sector in the country. The key to success lies in a systematic approach and the consistent implementation of planned measures with the active involvement of all stakeholders.

It is important to emphasize that the reform of the personnel training system must go hand in hand with the technical modernization of the energy sector itself, thus creating a synergistic effect for the long-term sustainable development of Uzbekistan's energy sector.

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