



Efficient Modes of Advance Training the Masters of Chemical Engineering

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ABSTRACT

Today, the fuel and energy complex (FEC) is the basis of national economy, providing both the current performance and development of the country and a large proportion of the budget revenues in the Russian Federation. Considering the vigorous growth of the oil and gas industry, knowledge workforce are in demand, which are able to apply their professional skills to production processes and be involved in implementing investment projects in the oil and gas sector. The network process of education provides the enhancement of training quality and allows accumulating the best practices of leading foreign and national educational institutions and bringing up to date educational programs considering the level and special features of the resources provision for real professional facilities.

Keywords: chemical engineering, educational programs, advance training, masters

INTRODUCTION

Urgency of the Problem

The high level of scientific research and latest technologies in oil and gas extraction, transportation and processing requires the continual improvement of vocational training the personnel for petrochemical enterprises. A special attention is paid to training masters that have highly specific knowledge, are able to critically re-evaluate their results, and are capable of solving problems, creating and integrating interdisciplinary knowledge, managing and transforming specific elements in the field of their study, which elements are characterized by complicity and unpredictability and require new strategic approaches.

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The global and innovative nature of the industry tasks determines the necessity of introducing the advance vocational training of masters. Implementing such advance educational process actualizes the research in the criteria of ensuring its efficiency.

Importance of the Problem

The quality of master-level vocational training depends largely on solving the innovative problems of petrochemical complex development. Petrochemical outlook is described in the Energy Strategy of Russia for the period until 2025 [1]. Among the main areas, the following can be emphasized:

- Sustainable using the proven oil reserves,
- Ensuring the on-a-large-scale reproduction of the oil-producing industry raw materials base;
- Efficient using resources and energy and reducing losses at all stages of processing while oil pretreatment, extraction, transportation and refining;
- Advanced oil refining and comprehensive extracting and using all valuable associated and dissolved components;
- Establishing and developing new large oil production centers, first of all, in the eastern areas of Russia and offshore blocks at freezing and Far-Eastern seas,
- Upgrading the existing oil-and-gas processing and petrochemical production facilities, and
- Developing and assimilation of novel technology.

Status of the Problem

Advance education, unlike the conventional one, is focused on training professionals not so much for preparing them for a specific professional activity as for forming the readiness to learn new knowledge and multifunctional skills, ensuring the occupational mobility and competitiveness of a graduate meeting the requirements of the contemporary and future labor market.

Researchers have already performed the longitudinal studies of the advance training principle in respect of modernizing and reforming the educational system in general and vocational education in particular.

Recently, the place and role of a person in modern economy and production and the new requirements thereof regarding the personality of an employee and his or her professional qualities from the advance-educational point of view have been considered in the works by Klimov [2]. However, the studies considering advance vocational education, in terms of its characteristics, conditions conducive to it, and its efficiency, are occasional.

Hypothesis

Our analysis of theoretical studies and practical activities regarding the problem under research revealed that the issues concerning the advance vocational training support for highly-qualified professionals currently remain an understudied area of scientific knowledge

and practical activities. This allowed us to develop the hypothesis of researching in this problem: Training competent masters in chemical engineering will be successfully delivered, if the network forms of educational process are used in advance vocational training of future engineers.

Objectives of the Study

The hypothesis stated above has defined the objectives of our study:

- 1) Monitoring the employers' requirements for the quality of vocational training the masters of chemical engineering;
- 2) Analyzing the content of training the masters of chemical engineering;
- 3) Developing and implementing the innovative forms of master-level vocational training; and
- 4) Estimating the efficiency of network educational process in master-level training.

METHODOLOGICAL FRAMEWORK

Development of the Concept of Advance Education within Historical Context

Historic and pedagogical analysis of the conceptualization of advance education allowed us to set forth the preconditions of using it in vocational training the personnel for petrochemical industry. The actuality of advance vocational education is dictated by the need of forming innovative economy, so its main purpose is satisfying the need of its industries in prognosis-focused highly-qualified personnel. Advance education is introduced in accordance with the lifelong learning concept. The necessity of training the personnel in accordance with the requirements of developing the innovative economy predetermines creating the conditions that empower a person to choose his or her personal educational path. In case of advance education, four vectors of motion are possible within the educational environment: Moving forward, moving upwards, moving sideways, and short-term moving downwards to form basic occupational competences, if required by the employer.

Content of advance vocational education must both meet the requirements of production and labor market and be focused on anticipating their current level and state. The basis of forming the educational technology is the acquisition of the knowledge core and the enrichment of its shell [3].

Subjects of advance educational process are: Students, teaching personnel, and employers. The core result of advance vocational education is formation in a person of the capability of proactive knowledge incrementing and developing transformative intellect, the most important component of which is the capability of innovative activities [4].

Summarizing the results of prior studies, we can assert that advance educational process must be characterized by high innovativeness.

Conceptual Foundations of Advance Vocational Training the Personnel for Petrochemical Industry

The purpose of the advance vocational education system, determined by the specific nature of the status and prospects of developing the petrochemical industry, is educating competent, prognosis-focused and innovative personnel capable of providing the improved competitiveness of petrochemical products, expanding the capabilities of petrochemical and oil refining facilities, quick changing the techniques, implementing energy and resource saving technologies, and transferring to alternative hydrocarbon resources.

The system of advance vocational training the petrochemical personnel shall be formed in a regional education-research-manufacturing complex (RERMC) ensuring the integration of education, science and production.

The regional petrochemical education-research-manufacturing complex of the Republic of Tatarstan is a total of all manufacturing enterprises, scientific institutions and research and production companies, business entities, financial, marketing, consulting, expert and data providing companies, and institutions of vocational education, all performing their activities in the of oil-and-gas extraction, petrochemical and oil-and-gas refining sector, and mutually reinforcing.

The core of the regional education-research-manufacturing complex is the research-and-production petrochemical cluster of the Republic of Tatarstan, comprising industry enterprises, research institutions, industry-based businesses that most frequently act as test areas for innovative technology, and innovative technology transferring organizations.

The research-and-production petrochemical cluster includes the petrochemical and oil-and-gas processing research-and-educational cluster of the Republic of Tatarstan, which consolidates institutions of vocational education and profession-oriented schools that perform vocational training; basic industry enterprises that support mutually beneficial cooperation with educational institutions in the field of training and professional development of personnel.

The basic methodological approaches to designing the training system are the systematic, resource-based, person- and activity-centered, competency-building, prognostics-based, and cluster approaches [5].

The content of advanced vocational training the personnel for petrochemical industry is defined by the requirements of its innovative development and regulated both by the principles of general pedagogy, such as scientificity, educational content continuity, problematicity, and professional direction, and by specific principles, such as regional nature, integration, learning augmentation, differentiation, flexibility, advanced development of vocational education, social partnership, motivation, and focus on personal development.

Introducing the process of advance training depends on the developmental level of needs and motivation, as well as the readiness of all educational process subjects for advance training.

Trends and Features of Vocational Training the Masters of Chemical Engineering

Prospectives in the development of petrochemical industry determine the changing nature of occupational activities, since its development is, directly or indirectly, driven by science, technology, and production. The modern engineer ensures the safe and efficient functioning of existing and new operating procedures, has the skills of applying new scientific methods and information technologies when researching in and introducing such new procedures, can develop innovations, as well as evaluate and implement innovations, is economically literate, and improves the production process and control.

Trends in changing the content of professional activities, determined by the outlook of innovative developing the petrochemical industry, indicate creating the relevant conditions for training highly-qualified professionals capable of ensuring the industry's breakthrough development.

Today, the university-educated personnel training system is characterized by the disparity between the school leavers' knowledge levels and the requirements of colleges/universities; by the insufficient linkage between the system of higher education and the labor market at federal and regional levels; by the obsolescence of the universities' training and laboratory facilities and resources; by the low rate of the graduate employability in their degree fields; by the lack of vertical and horizontal interconnection among the institutions of vocational education; by the low level of integration of universities with the research institutions of the Russian Academy of Sciences and with the industry research; and by the lack of modern economic tools within the system of higher education.

The results of evaluating the status of vocational training the personnel for petrochemical industry indicates changing the content and the organization of such training and allows us to state the leading trends in advance training, such as the diversity-based fundamentalization of training, as well as the complexity, computerization and international focus of the educational process.

Network Forms of Educational Process as a Tool for Improving the Efficiency of Advance Vocational Training

One of the important conditions to efficiently implement advance vocational training the master of chemical engineering is the organization of innovative educational process.

Innovations in educational process are actions aimed at satisfying the new need of training personnel capable of accelerating the development, transfer and implementation of new equipment and technologies and of producing new, science-intensive products demanded by consumers. Innovations in educational process are related to both introduction of innovations and the use of efficient ideas, knowledge, and modes of operation to solve new problems [6, 7, 8].

Among innovations, the organization of a network educational process can be distinguished. Network-based implementing educational programs enables students to successfully complete educational programs using the resources of several organizations performing educational activities, including foreign ones, and also using the resources of

other entities, if necessary.

The purposes of network education are:

- Improving the quality of education through integrating the resources of partner organizations in the priority areas of sectoral, multisectoral and regional development in accordance with international standards;

- Training personnel having unique competences that are in demand in the priority sectors of industrial and regional economy and on the labor market;

- Implementing national and international best practices into educational process to develop applied research for industry enterprises and regional companies.

The common network forms of interaction between universities and the industry are: Employer-sponsored specialist training under contract, establishing the university's branches or specialized departments at enterprises and research companies, arranging industrial work placements, and establishing business incubators, technopolitan areas, and small investment companies – corporate centers.

Forms and methods of network interaction between a particular university and an enterprise are chosen depending on the purposes pursued by such university or enterprise; on the technology underlying the manufacture at enterprises; on the research focuses of universities; on the availability of financial resources; etc.

Interaction in the format of implementing university network educational programs is considered by academic and professional communities among the promising forms of the integration of education, research and production. Specific requirements for designing the concentration programs are as follows:

- Ensuring the continuity and succession of educational levels and contents;

- Specifying the integrated internship program as the key section of an educational program;

- Increasing the elective component of the Master's program up to 70 %;

- Developing program contents upon the requests of enterprises, considering the specific features of processing at particular facilities;

- Focusing the specialized internships and the topics of graduate theses on the requests of enterprises; and

- Adding subjects/modules that are realized using academic and technology basis of intellectual contribution made by the leading specialists of an enterprise.

Introducing the network educational programs will ensure training professionals having well-developed competences of standard when used at a specific manufacturing location and being ready for manufacturing and/or research and processing activities that comprise, along with applied research, developmental work and planning and surveying activities and suggest the elements of innovative activities.

RESULTS

Subjects of Advance Training the Masters of Chemical Engineering

Sectoral clusters create the best environment for implementing network educational programs. This is related to the possibility of solving the following problems: Assuring the compliance of the educational services market with the labor market; motivating all people involved to efficiently train professional personnel; developing a concerted strategy of personnel training; creating a common education space within the system of continuing education; developing a unified knowledge base; joint solving fundamental and applied problems; creating an organizational and economic tool of training qualified personnel; and efficient using the facilities and resources of all cluster participants.

The Kamsky Center of Cluster Development of Small and Medium Businesses of the Republic of Tatarstan is one of 25 innovative clusters in Russia. Its industry specialization is oil-and-gas processing, petrochemical production, and automotive engineering. The research and educational complex of the cluster includes Kazan National Research Technological University (KNRTU), the leading technological university in Russia. It offers over two hundred Master's programs within the advance training system, which ensures the graduates' high initial opportunities on the labor market. The practical focus of vocational training is provided through the university's interaction with large Russian enterprises, such as PJSC Kazanorgsintez, Gazprom PJSC, PJSC Tatneft, LLC LUKOIL-Nizhegorodniiproject, LLC Alabuga-Plastic, JSC Kazan Synthetic Rubber Plant, Kazancompressormash (Kazan Compressor-Building Plant, Russia), etc.

Organizing the process of education at the specialized departments in sectoral research institutes contributes to ensuring the compliance of research and project-focused training of future engineers with the industry-specific elements. Such university's partner is, for example, LLC LUKOIL-Nizhegorodniiproject, Nizhny Novgorod, a research and project-focused institute specializing in oil processing. To solve the industry-specific tasks of phasing out imports, as well as developing and implementing new efficient processes and technologies and promising catalysts and reagents, KNRTU in close cooperation with the industry-leading institutes, such as OAO VNII NP (All-Russian Research Institute of Oil Refining), Institute of Petroleum Refining and Petrochemistry of the Republic of Bashkortostan (INKhP RB - BASHNIINP), and one of Russia's largest oil companies, PJSC TATNEFT, have established the center of horizontal network cooperation.

Network Educational Programs of Project-Based Master's Training

According to present knowledge, a significant improvement of the customer appeal of a graduate as a product of the system of higher education can be achieved applying the project-focused approach to personnel training. The process of training masters in planning and process engineering can be considered as the most indicative example of its realization. Regarding the trends in the development of manufactures, this is a very actual and still organizationally very complicated field of education requiring the network interaction among the partners.

A Master's program in Planning and Process Engineering must have specialized processing and planning competences and excellent skills in handling technical documents, including those drafted by foreign companies according to their corporate standards. Excellent handling skills imply the ability to read foreign technical documents, as well as the ability to assign tasks for developing similar technical documents, control task performance and volumes, and communicate with foreign professionals on equal terms within the internationally recognized conceptual framework [9].

Developing project-focused competences in future engineers is ensured by training in 3D designing the oil-extraction, oil-processing and petrochemical processes, using advanced software, such as AutoCAD, Integraph Honeywell, CADWorx, UniSim, and Aveva PDMS. This is strengthened by organizing the educational process in the office of the major department, located at LLC LUKOIL-Nizhegorodniiproject. Content of the educational program, in addition to mandatory federal components, includes training in three-dimensional simulating and designing, general civil planning, fundamentals of energy audit, project management and turnkey construction, fundamentals and prospects of petrochemical business, as well as studying processing equipment and practices in the treatment and processing of oil and raw gaseous hydrocarbons [10].

Master students having a basic command of the scientific bases, techniques and methods of integrated oil refining aimed at extracting valued components and producing oil products having predefined properties, are trained on the basis of oil processing enterprises, such as JSC TANECO. Specialized software, such as process simulation programs (simulators) are used in the educational process. Studying a virtual process prototype helps master students quickly adapt to the real manufacturing environments. Master's theses are supervised by the employees of enterprises and co-supervised by the university's faculty members.

In order to support the research base of master's training, KNRTU established the integrated laboratory named Oil and Gas Engineering and Gas Chemical Engineering in Primary Polymers Production in cooperation with Gazprom PJSC and the basic department titled Designing and Advanced Processing Raw Hydrocarbons in cooperation with OAO VNII NP.

Integrating human and resource potential of the industry when realizing process engineering training ensures the graduates' readiness for occupational activities within petrochemical industry.

Network Internationally Integrated Master's Programs

Internationalization of higher education creates a favorable environment for providing the advance nature of educational process. This encourages colleges/universities to intensify international engagement among themselves and with other industry-specific partners. Internationally integrated network vocational training programs are considered among the positive results of the globalization of education.

The joint educational program named *Engineering of the Lean Production of Organic Chemicals and Petrochemicals* provides forming highly-specialized knowledge in the masters

of chemical engineering, capable of using LEAN technologies to perform constructional engineering and implement new or modify the existing processes and manufactures of promising substances and materials. The program is jointly realized by KNRTU and the University of Chemical Technology and Metallurgy in Sofia, Bulgaria, where graduate students do practical research and prepare analytical reviews for the topics of their master's theses.

The prospects of developing catalytic technologies require training experts in catalysis. Considering the complexity and high specificity of developing competences in process engineers, it would be efficient to train them involving the largest global leaders in industrial catalysis and leading research centers. High-performance training is provided within the Master's program named *Catalytic Technologies in Petrochemical and Refining Industries*. In implementing the program, theoretical classes are given by KNRTU and the Technical University of Denmark, while all kinds of practical training were developed and are organized by Haldor Topsøe A/S, Denmark - the largest company licensing catalytic technologies.

Efficiency of the Network Forms of Advance Vocational Training the Masters of Chemical Engineering

The efficiency factors of the network forms of advance training the masters of chemical engineering are as follows:

- Increased relevance of the graduates on the industry labor market;
- Changes in the characteristics of the graduates' employment;
- Positive dynamics in the graduates' career growth within 2-3 years at the innovative facilities of petrochemical industry; and
- Increased number of students getting further education.

Based on the results of the master students' manufacturing activities and graduation paper presentations, the managers of the manufacturing departments of enterprises and the faculty members of KNRTU provided the most positive feedback regarding the levels of their knowledge and professional qualifications.

DISCUSSION

The basic premise of researching in the efficient forms of advance vocational training is the innovative onrush of chemical technology, the support for which requires highly-qualified engineers - masters in chemical engineering.

Networking the subjects of innovative educational process enhances the efficiency of vocational training and ensures developing in future engineers the following:

- Readiness for personal development, self-realization, and the use of their creative potential;
- Ability to pursue professional passions and independently learn new methods;

- Readiness for changing the scientific, research and production profile of their occupational activities;
- Ability to professionally operate advanced equipment and devices;
- Readiness for protecting and commercializing intellectual property rights;
- Ability to quickly be up to speed on innovative upgrading the industry;
- Ability to forecast changes in manufacturing;
- Ability to develop, evaluate, and implement innovations;
- High level of creative thinking and social adjustment.

The University students evince a strong interest in learning in the real manufacturing conditions. Graduates confirm their rapid adaptation to occupational activities.

Employers' interest in implementing the network form of study is also proven by the increasing number of specialized training contracts the University enters into with them.

CONCLUSION

Meeting the requirements of the innovatively developing petrochemical industry for vocational training, taking the advance education principle into consideration, allows us anticipate a fundamentally new vocational training process. Therefore, to transfer to it, the conditions must be created, such as providing the integration of education, science and production, the high degree of training content development, the improvement of organizing the educational process, the psychological and educational readiness of students/trainees, the competences of teaching staff, and the availability of relevant facilities and resources in the vocational education institutions.

Thus, using the network forms of advance training the masters in chemical engineering, implemented in the conditions of integration of education, science, and production, promotes developing in young professionals the focus on innovative upgrading in the industry, the high standard of professionalism, the ability to predict changes in production, and the ability of developing, evaluating and implementing innovations and developing the high-level creative thinking and social adjustment.

RECOMMENDATIONS

The results of the research pursued can be recommended for the teaching personnel of the institutions of vocational education in organizing educational process, designing training content, and arranging the interaction with employers. The experience gained can also be recommended for the personnel of research and design organizations and production facilities to be used in developing human resources policies.

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