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Practical-Modular Training in Engineering Education: Problems and Solutions

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Abstract— **To improve the quality of engineering education, deepening the practical training of students, it is necessary to improve the structure of the educational process, to search for new teaching methods that meet the state-of-the-art techniques and technology. The modern state of the system of engineering education and scientific approaches to improve the didactic process are analyzed. The solution of the problem of engineering personnel training is considered in the direction of improving practice-oriented methods of teaching, developing the principles of systematic and consistent connection between theory and practice. The review of research on the practical-modular approach to the organization of the educational process is given, its historical roots and the current state studied. The necessary proportions for the qualitative training of engineers between theoretical and practical training are analyzed. The results of practical-modular training in the preparation of bachelors are presented. The ways of further development of practical-module education in the system of engineering education are suggested.**

Keywords—quality of engineering education; practice-module training

I. INTRODUCTION

Increasing requirements for the quality of engineering education poses the task of finding solutions in the training system. The solution of this problem is possible only with a comprehensive approach on the basis of an analysis of the problems of the quality of training specialists in higher education and in particular in engineering specialties, the reasons that have caused these problems, the development of the society, the state and dynamics of economic development [1].

Undoubtedly, ways to solve the problem of improving the quality of training specialists should be based on the developed long-term strategy for the development of the entire education system in Russia, as well as on more specific programs for the development of certain areas in education, including engineering education.

II. RELEVANCE

The education system affects all spheres of public life and all categories of the population. In the sphere of education, most developed countries are engaged in the search for reforming the education system, creating the most effective university structures that meet the demands of the society for the training of qualified personnel [2, 3, 4, 5, 6].

Reform of education is a strategic goal of the country's development and a further basis for a successful, with the accelerated development of productive forces, technologies, technology [7, 8]. Therefore, the forthcoming reforms should be widely discussed among the scientific community, university workers, general education workers, business representatives, employers, etc. The society should become an active inspirer and participant in the forthcoming reforms.

III. TASKS FORMULATION

Undoubtedly, when considering the problem of improving the quality of education, the professional level of the teaching staff and its moral and ethical principles are put first on the list [9, 10]. When considering the issues of the development of education, the quality of training is very rarely seen in connection with the provision of resources: financing, labor (they are often not taken into account, it is assumed that everything is solved by itself), a modern material base. The qualitative composition of the reformers occupies a special place in this chain: who develops reforms, who nominates them for this function, what is the professional level of the reformers, work experience in relevant spheres of activity and achievements.

Feverish changes in the structure of training, standards, competence requirements not only do not allow to provide the current educational process, but also throw it back. At the same time, time is lost, reforms are stalled, the expected result is not obtained. It is not always possible to harmonize school preparation, for example, in mathematics with the required level of knowledge in this subject in technical universities [12, 13, 15].

Currently, the social order, the demand for graduates with engineering training, as well as the quality of their preparation are very different in different sectors of the economy [16, 17]. This is predetermined by the traditionally high level of individual industries, for example, military-space, attention to the system of scientific and educational provision of these industries by the state. Of great importance is the economic condition of individual industries at this stage of the development of society, their reserves and opportunities, the established system of the international labor market, technology, equipment and services.

The system of higher education is a multifaceted substance with accumulated traditions, high intellectual potential,

somewhat conservative, which is sometimes useful in attempts to unreasonable administrative reform to achieve immediate benefits. At the same time, despite the seeming conservatism, sluggishness, the complexity of internal links between the subjects of this activity, it adequately responds to requests, challenges, tasks that are objectively necessary for the society and economy of the country.

The search for ways to reform the global education system does not exclude the improvement of certain methods, structures of educational programs, forms of interaction between higher education and employers and partners.

IV. THEORETICAL PART

One of the problems in the training of engineering personnel is the inadequate preparation of graduates for practical work and, in particular, practical skills and abilities.

Such a problem exists, but it cannot be absolutized. The ratio of the theoretical and practical component in the baggage of a graduate should be determined by the profile of his training or specialty: this graduate will perform operational functions or engage in, for example, strength calculations and design and technological preparation of production. Within the framework of a short educational process, for example, for a bachelor's degree this period is 4 years, the proportions between the theoretical and practical components must be very clearly verified.

The emerging need for practical skills and skills for a particular production can be successfully overcome directly in this enterprise. The absence of elements of the necessary fundamental training of a specialist within the production process is much more difficult to reconstruct. Therefore, strengthening the fundamental training of engineering education is also an urgent task [18].

The solution of the problem of preparing students for practical work is possible in two ways. The first direction is the preparation of students for additional educational programs with the participation of enterprises. This should take into account the specifics of the enterprise.

The second direction is the development of training programs, which include blocks of intensive practice-oriented nature. This will increase interest in the educational process on the part of students, fill the learning process with practical knowledge and skills and, in general, activate the educational process, including in the direction of fundamental training.

Realization of the second direction is possible with the application of practice-module training, in which the educational process for individual disciplines or their practical components is carried out at manufacturing enterprises. At the same time, the material base of a specific enterprise and their personnel are involved, the necessary links of higher education institutions with enterprises are strengthened, and mutually beneficial convergent structures are created.

In a number of scientific papers on pedagogy [19], modular instruction is presented as a holistic and systematic approach to the learning process, which ensures the effective implementation of the didactic process. General provisions of modular training were developed in the late 60s and 70s of the last century by English and American theoreticians in the field of vocational education: BF Skinner, J. Russell, K. Kurh [20]. In particular, J. Russell defined the module as a training package that encompasses a conceptual unit of educational material and prescribes actions to the learner [21].

In the domestic pedagogy, the problem of modular training is devoted to the works of Yucevichene P.A., Choshanova M.A. [22]. The module is an autonomous organizational and methodical structure that includes didactic goals, a logically completed unit of educational material, a methodical manual, including didactic materials, and a control system.

To improve the motivational factors for acquiring professional competences in the training of students, the answer to the growing demands for the development of these competences on the part of employers requires in some cases the improvement of educational learning technologies in the direction of the transition from knowledge transfer to a practice-oriented approach.

Currently, the following groups of practice-oriented technologies of education in the university are distinguished [23]:

- interactive training;
- context-based competence training;
- Modular training;
- Self-regulated training.

Let's consider in more detail the above technologies of training. Interactive training consists in the transfer of knowledge and the simultaneous involvement of all students in the work, this training is in cooperation, which consists of discussions, brainstorming, the use of visual aids, computer technologies, etc. [24-26]. Context-competence training involves, along with traditional forms of quasi-professional activity (laboratory work, excursions to enterprises, work in training workshops). Modular training is aimed at solving long-term complex tasks with a structural breakdown of the educational process into interrelated modules, allowing to ensure a full cycle of training.

Self-regulated training is the development of students' abilities to independently acquire the necessary competencies. In a rapidly changing social environment, self-regulated learning will allow for more in-depth knowledge of individual disciplines. The depth of knowledge and the effectiveness of their assimilation will depend on the level of preparedness of the student. In general, this approach to learning will improve the level of training of students.

In the training of students in engineering areas self-regulated training can be effectively combined with the implementation of individual tasks for the calculation and design of machines and mechanisms.

Thus, practical-modular training can be characterized as structured training in complex, functionally complete modules intended for the mastery of academic disciplines or its individual components. Practical-modular training is based on

the consolidation of acquired knowledge through practical cognitive activity.

A number of criteria for implementing practical-modular training and achieving the goals (individual approach to teaching students depending on their level of general education, teamwork, etc.) theorists of didactic science is considered in relation to humanities education. In engineering education, these issues require substantial refinement, and in some cases, at the theoretical level, they were not considered at all.

The analysis of the theoretical studies on practical-module training, as well as the practical application of the results of these studies, makes it possible to draw the following conclusions and present the main directions of the development of this method.

1. A more detailed scientific study of the didactic process of engineering education is required in conjunction with rapidly developing technological progress, its requests to the education system. In a number of positions, didactics must outpace this progress, predict its demands.

2. It is necessary to scientifically substantiate the development of educational standards and programs, standards for the application of methods and means of instruction, depending on the level of the educational process, its orientation. The structure of the educational process should provide for the correlation between the theoretical and practical component in the training of a specialist, depending on the type of future activity.

3. The basis for applying practice-module training as a method should be carried out taking into account its place in the educational process, goals and tasks to be solved.

4. The development of practical-modular training as a method is possible in the following areas:

4.1. Organization of training at enterprises implementing the production process.

4.2. Organization of training at enterprises with specialized training centers.

4.3. Compatibility of practice-module training in an enterprise with training or production practice.

4.4. Creating in the universities of their own training and production centers. It is possible to conduct part of the training sessions at the enterprise.

4.5. Increasing the number of didactic units for computational and graphic work, term papers and projects, as elements of practical-modular training.

An increase in the hours of individual work of the teacher with the student will make it possible to implement one of the principles of practice-module education - an individual approach. This is an integral feature of engineering training.

The implementation of integrated coursework and projects, including those commissioned by enterprises, will enable students to gain the skills of working as a team in solving engineering problems, and enhance the student's personal status.

4.6. Realization of additional educational programs for students on the order of the enterprise providing employment of graduates, with practice-modular blocks.

4.7. To receive additional specializations and training profiles for students on interuniversity exchange, taking into account the requirements of employers.

The implementation of the last point is expedient in the case when the required educational program is not available in this institution, and the enterprise's need for these specialists is low. In this case, there is no need to organize full-scale training within the framework of this institution. It is more profitable for the enterprise to send students of the last courses of related specialties or training profiles for training on interuniversity exchange of students.

4.8.Professional development and retraining.

Students of these courses have different competencies, and in retraining students often have different basic education. It is necessary that the implementation of the educational program was carried out for the bulk of the audience. Individual modules of this program should provide training for the remaining trainees, depending on their educational level. In this case, students can partially work on the development of the educational program independently. The teacher should have a consulting and coordinating function.

To align the competencies of students, you can also recruit groups to train on individual modules. At the same time, the number of students should be sufficient to form separate groups.

4.9.Training of specialists for work in the field of design and research activities.

A special emphasis in this direction should be placed on the development of self-learning skills. Practice-a modular learning in this case should be directed to the solution of complex engineering and research problems.

V. PRACTICAL SIGNIFICANCE

Realization of practical and modular training in the block of general professional disciplines of the bachelor's direction "Oil and gas business" in the Tyumen Industrial University showed the effectiveness of this method of training.

The use of modern material and technical base of enterprises, holding classes by employees of these enterprises allowed to strengthen the practical orientation of the learning process, to increase the motivational factors for students. When diagnosing training, an increase in achievement by 20% was recorded.

Practical-modular training will allow reorganizing the learning process quickly, depending on the needs of enterprises. For example, it will be possible to enter specific blocks of subjects in the last years of study based on upcoming employment. In this case, the period from the demand of the enterprise for a release of specialists before their receipt will be reduced and the necessary set of competencies will also be

provided. It will be possible to provide various trajectories of the educational process in the curriculum. The implementation of these trajectories will have to be carried out depending on the current needs in training.

This approach will allow providing specialists to new fast-growing enterprises, to provide the regions with advanced development personnel.

Implementation of practical-modular training also will allow optimizing the learning process through the unification of disciplines in the first and second years of study. Practical-modular training in the last years of study will allow getting the necessary competence in a shorter time.

The introduction of practice-module training has its own peculiarities, requires careful organization of this process, reliable and long-term links with industrial partners, additional resources for management of the educational process and financial costs. Particular attention should be paid to the following issues:

- the readiness of enterprises to receive students for practical modular training (the consistency of the work schedule of the enterprise and the schedule of the training process, the stability of the fulfillment of contractual obligations in this matter, the availability of jobs, an audit fund, overalls, materials and tools, a canteen, etc.);

- availability of specialists at the enterprise who are able to conduct training sessions, and a time resource for these purposes (in some cases, restriction of excursions);

- the possibility of flexible implementation of the schedule of the educational process in accordance with the mode of operation of enterprises;

- availability of financial resources in the university to provide additional costs.

VI. CONCLUSION

Thus, practice-module training allows you to form a competitive specialist, more adapted to the ever-changing needs of enterprises. The modular principle in the organization of the educational process provides flexibility in providing the required competencies. The practical component raises the motivational factors of students, reduces the time of industrial adaptation of a specialist. In general, all these components ensure the quality of the educational process in accordance with the demands of the labor market.

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