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Innovation Approaches to Development of Educational Programs in Field of Engineering

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The article is devoted to the main conditions of effective development and design of educational programs in the field of engineering.

Key words: educational programs, individual route, competences.

Intensive processes of structural changes, that take place in Russian economy, have stipulated high demand for new age specialists, who could successfully implement these changes with reference to the current historical, economic and political situations in the country. Practical activity, interests of economy, intensive development tracks that are taken by our country, have to prescribe the goals, methods and contents of higher education. However, modern education at national HEIs is insufficiently focused on resolving innovative problems. There is a critical shortage of HEI graduates, who have a high level of technical competency.

It is only possible to ensure a high quality of engineering specialists' training by having an efficiently functioning "Science – Industry – Market" system.

The key role in this system is given to the applied sciences – the source of scientific and technical innovations that determine progressive trends for advancement of products and services both in techno-economic and in social contexts. Undoubtedly, the market demand and the follow-up diversification of the production to a great extent influence the applied research trends. However, the breakthrough innovations that qualitatively alter the end-user characteristics of produced goods and services can drastically affect the market environment. Thus, the dialectics of the "Science – Industry – Market" system's development emphasizes the need for "elite" specialists training based on individual programs in the field of new engineering solutions' synthesis at the interface of different scientific fields that require deep technical knowledge and mandatory experimental research training [1, 2].

At the present time, implementation of the international quality standards, educational and professional standards, credit system and other conceptually new modifications to the system of HEI graduates' training leads to the emergence of some significant challenges in development of engineering educational programs that would be innovative, competitive and creative.

In response to the implementation of credit system to the students' educational process the main goals are:

- standardization of the scope of knowledge;
- creation of conditions for the highest personalization of education;
- strengthening the role of student's self-study efficiency.

The set goals and objectives of engineering graduates' training are most efficiently reached when the following key preconditions are respected: organization of applied Bachelor's Degree programs (existence of practical training resource center), development of practice-oriented units of educational programs, realization of dual education system, arrangement of individual paths for grasping the educational program, proficient use of e-learning elements, engineering of

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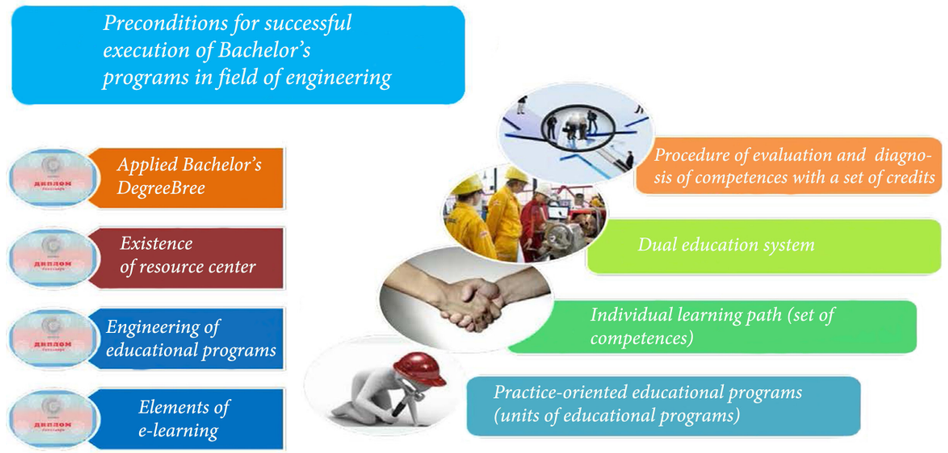
educational programs (Fig. 1).

Dual education is a form of specialists' training that combines theoretical education within the educational institution (30-40% of study time) and practical education at a production enterprise (60-70% of study time). The main feature of a dual education system is the equal responsibility of both educational institutions and enterprises for the quality of specialists training.

The idea of dual education is to attain its real practical outlines. Interaction of education with business and other market agents is one of the elements of a modern model that is highly sought by the society. Therefore, now is the right time for the global support of the dual education, and the work on its realization should be continued in close collaboration with employers and social partners interested in the development of dual education.

The central object of dual education is the trinity of the participants: educational institution, student – the trainee, and the enterprise. Dual system respects interests of all the participating parties. For the educational institution it gives an opportunity to increase not only the graduates' competitiveness, but also the competitiveness of the educational programs. For the enterprise it gives an opportunity to prepare specialists for itself, to lower the expenses intended for the headhunting and recruiting of employees, for their re-education and adaptation. Thus, it is economically reasonable for employers to "invest" in education, since "on return" they will receive a ready-to-work specialist, who will know in minute detail all the peculiarities of working at

Fig. 1. Preconditions for successful execution of Bachelor engineering programs



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the specific enterprise (organization). And for the student, in line with the optimum transfer of the professional experience, it provides a completely new degree of socialization: students are involved in real training and testing of their attitude in the real-life working conditions. This is the reason for their fast adaptation to the real working conditions and a high possibility for successful employment after graduating the educational program [3].

When executing educational programs that comprise the dual education system (in our case it is the specialty of "Transport processes technology" and "Service") a specific model is implemented, where students attend classes at university 3 times a week and study the theoretical and fundamental basics of science, and spend 2 days conducting practice learning at the production site [4]. At the enterprise, students work under the direct supervision of specialists – acting workers with high level of acknowledgement. Such enterprises of the Kaliningrad region, as LLC "Autotor", dealer centers of Toyota and BMW, etc., serve as production sites, resource centers for practical training at Immanuel Kant Baltic Federal University.

The advantages of the dual educational programs are as follows:

- elimination of the key problem of traditional forms and methods of education – the gap between theory and practice;
- emergence of extra possibilities for enhancement of engineering specislists' training efficiency;
- diversification of higher education that means enlargement of a variety of proposed educational and professional programs;
- stimulation of a more miscellaneous professional development of students;
- providing interaction, interpenetration and mutual influence of different systems (science and education, science and industry, etc.) that lead to qualitative changes in formation of key professional competences of future HEI graduates;
- increase of professional mobility and graduates' competitiveness on the labor market.

One of the key elements of the dual system is the impartiality of learning outcomes assessment, granting of certificates for "specific" competences, abilities and skills. The assessment of competence level in dual education system is the affirmation of the existence of qualification, of the acquired experience of practical activity. This assessment is focused on the determination of skills in the context of finding solutions for professional problems that require application of information from various fields of knowledge, update of skills and knowledge in new situations, accomplishment of universal types of activity. Thus, we have come to a conclusion that the basis for composition of the dual education system is the designing of student's individual learning path (individual route for grasping the educational program) taking into consideration his/her abilities, personal dispositions and interests.

When speaking of the personalization of the educational process it is essential to note that such methodology allows each student to choose one or another dual educational program and not be dependent in this choice from other students. Such organization of the educational process led to the emergence of a need for student's interaction with a consultant (program manager, tutor, etc.) during the whole study period. Therefore, the following elements were included in the job functions of these specialists: professional consultations on the contents of educational programs and its requirement; specification and correction of student's individual choice and development of a flexible learning path based on his/ her choice in line with the conditions, determined by the educational program.

In our perception, the individual route is a well-defined system that includes

requirements (expressed in learning outcomes or fostered competences) for the educational program's learning outcomes, connected with specific requirements for professional activity, as well as it is a plan and a "starting point" for learning the proposed contents.

This, of course, requires not only the "readiness" and motivation of students, but also very deep modernization in terms of design and development of courses (modules), as well as teaching methods and tools or the "teaching interaction" with students from the point of teachers.

In our opinion, in the context of realization of engineering educational programs, it is necessary to introduce the individual route very carefully, since the graduate's professional activity has to differ not only from the point of practical path, but from the fundamental one as well. Therefore, in such a case, a full freedom of choice does not always positively affect students' competence formation. We propose a methodology for development of student's individual path, where the chosen set of competences integrates not only with the educational program's learning outcomes preset by the "purchaser", but also with the courses' (modules') learning outcomes.

Personalization of the educational process implies execution of a full complex of learning methods, which results in an opportunity for each student to show his/her personality, translate the maximum of his/her opportunities into action and, at the same time, stay above the level of advancement set by the educational goal.

The conditions for this approach are as follows:

- determination of the initial level of individual working skills;
- determination of the initial knowledge level;
- allocation of students to different subgroups within one group according to their level of competency (high, middle, low);
- development of various tasks with different contents and knowledge scope for the same program material.

The personalization of the educational process is based on the asynchronous (non-linear) educational method that has the following features:

- high level of students' freedom of choice in terms of the curriculum courses;
- personal involvement of each student in the formation of his/her individual curriculum;
- involvement of the educational program's managers in the educational process (as academic consultants) in order to assist on the formation of educational path;
- mandatory application of the grade rating system for the assessment of student's level of mastery of a course.

Application of the individual educational approach results in justification of the opinion of scientists E. Goncharova and R. Chumicheva, who determine the competences that can be formed through execution of the individual educational trajectory of a student:

- Readiness to solve problems, i.e. an ability to analyze off-standard situations, set goals and correlate them with the aspirations of other people, plan results of his/her activity and develop algorithms for their achievement, assess the results of his/her activity; leads to making a responsible decision in any situation and assure its realization
- Technological competence, i.e. readiness to understand instructions, technology descriptions, action algorithms, full adherence to the technology of practical activities; allows students to foster and wisely implement new technologies, think technologically in various life situations
- Readiness for self-education, i.e. an ability to identify issues concerning his/her knowledge and skills when solving new problem, evaluate the need for certain information for his/her activity, conduct the informational search and retrieve information from various sources on any kind of devices; allows altering his/her professional qualification flexibly, self-mastering of knowledge and skills necessary for solving a preset problem.
- Readiness to use informational resources, i.e. an ability to draw reasonable conclusions, use information for planning and conduction of his/her activities; allows student to take responsible decisions based on critically revised information
- Readiness for social interaction, i.e. ability to correlate own aspirations with interests of other people and social groups, interact productively with other members of a group (a team) that is finding a common solution; allows using resources of other people and social institutions for problem solving.
- Communication skills (competences), i.e. readiness to receive necessary information through a dialog, to present and dispute in a civilized way own point of view within a dialog or a public speech based on the acknowledgement of a variety of viewpoints and respectful attitude towards other people's values; allows using the communication resources for problem solving.

When designing an individual learning path, one of the key questions is the efficient organization of the student's self-study activity, since the extracurricular learning activity serves as a logical continuation of the in-class learning and has to be defined by the educational program. This type of activity includes: working with the lecture materials, preparing for workshops, practices and lab classes, performing individual tasks, course works and theses. Its character, contents and scope depends on a particular study course. Such work is conducted under the supervision of a teacher, who gives a task, consults and sets deadlines for its completion. Students' self-study activity that is included in the educational process is performed without the direct involvement of a teacher, but on his assignment and at a specified time period. In this regard, students consciously strive to achieve the aim of the set task. However, in this case, the time input is not regulated by the schedule. Depending on his/her own abilities and efforts student sets the mode and duration of the work that is later monitored by the teacher during in-class learning sessions. Any self-study activity has to be presented externally – in oral, written or electronic forms [4].

In line with the above statements it is worth mentioning that for the successful exploitation of student's individual learning path a thorough revision (remaking) of course's content and learning methods has to be conducted by the teacher. Therefore, while executing an educational program in field of engineering teachers should commit to the following recommendations:

- Forms of self-study activity should be defined according to the study course, its aims and objectives, level of complexity and practical relevance.
- Student's self-study activity has to be executed in line with the personalization of tasks, as well as with the level of proficiency and dispositions of a student.
- Enhancement of student's self-study work efficiency and qualitative modernization of the educational process overall depends on the exploitation of innovation technologies.
- Application of the whole variety of students' self-study forms of organization allows the most efficient stimulation of cognitive activity of students [3].

When developing practice-oriented educational programs it is recommended to introduce the module technology for design and development of the corresponding

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curriculum. In such case, the curriculum represents a synergy of modules that includes associated courses, practices and other types of educational activity. Each module requires a clear definition of learning outcomes determined by the overall results of educational program's mastering. Module's learning outcomes have to be assessed with use of complying assessment tools that, together with the traditional forms of control, may include interdisciplinary educational projects.

Within the design process of an educational program based on engineering, specific attention should be paid to the design, which include creative application of scientific principles for design and development of facilities, mechanisms, devices, production processes and operations.

Introduction of engineering principles in the educational program permits formation of the following key competences required by modern employers:

- Selection of proper machinery, tools and technological equipment.
- Inspection of the production operations.
- Development of recommendations on its modernization.
- Development of technical sketches of details.
- Development of production technologies for details' production, etc.

Consequently, when developing an innovative educational program in field of engineering it is necessary to take the following actions:

1. Make a synthesis between professional and educational standards' requirements.
2. Structure clearly the descriptions of learning outcomes and fostered competences corresponding with the employers' requirements.
3. Develop educational programs, which, from the one side, are standardized according to the professional requirements, and, from the other side, assure personalization and differentiation of educational process.

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