

Aspects of Modern Engineering Education

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Abstract – This article discusses the problems of globalization, development of countries and their economies which fundamentally change the standards of engineering education. Now engineers need knowledge and possession of a larger number of competences than merely mastering narrowly qualified disciplines. The greater number of innovative disciplines are becoming additional study courses. It is worth noting an update of the methodology and characteristics of the content of subjects as the main conditions and principles for improving education in engineering universities. It is necessary to understand that the theory given in the learning process should be an integral part of the practice, and not just its complement. It is similarly in teaching methods. The material has to be learned by a student by at least 60–70%, (the remaining part is taken by practice). At the same time, about half of the information should be studied by students on their own.

Keywords – *engineering education, business schools, competences, public corporations, engineer, Bologna process*

I. INTRODUCTION

XXI century is the time of high-tech development. Russia is considered one of the leading countries bringing up highly qualified specialists. However, unfortunately, Russia is also a country where one of the global problems is employment. Young professionals are often not hired by companies that justify their answer with a lack of experience and practical knowledge. In part, employers are right. Many universities focus on the theory which is often not applied in practice. Theoretical knowledge is not bad, it is one of the forms of training specialists. Therefore, practice should flow from theoretical knowledge. To improve educational programs, the study of the theory should be carried out in practice while letting students immediately understand how to use the theory studied in practice correctly. Consequently, the first thing that should be changed in the structure of the educational process is to place a greater emphasis on practices not at the expense of theoretical education. Secondly, students have the opportunity to receive a "high-quality" theory from life experience by creating academic mobility at universities among teachers, students from other large Russian, or foreign scientific universities, people of

considerable achievements in science and business. Such lectures based on life experience can be much more productive.

At the same time, at the second stage, it is possible to involve students in the implementation of any projects. First, as observers of the work of professionals, after – as participants. Such levers for the shift of scientific education are necessary for personnel training as well as to allow to establish the relationship between the university and the employer [1].

II. CONCEPT OF EDUCATION

In the modern world, the terms of "education" and "upbringing" are being separated. However, it is worth noting that education as a process includes upbringing as well, since upbringing with its very ordinary and formal content can be fundamentally different. The way a teacher treats a student imprints on his development, the process of progressing through the material, the attitude to the subject (even if it is not his major, but simply an addition to broaden horizons), even the desire to learn the discipline.

It is not a secret for anyone that in Russia the law "On Education in the Russian Federation" is in force, according to which there are two levels of education. The first level is general education (pre-school and school sublevel. School includes primary, basic and full education). The second is professional education. It includes secondary, higher (bachelor, specialty, magistracy) and training of highly qualified personnel (graduate school, etc.) [2].

Russian system of higher education has its own traditions, unique features, and achievements that are recognized in the world. Along with the advantages of the traditional domestic education system, there are a number of shortcomings: focus on fulfilling a rigid state order, insufficient flexibility of general educational and professional programs, a weak focus on meeting the educational needs of the personality of each student. The general lack of reforms of the past decades lies in the one-sided direction of decisions, the desire to achieve results through the solution of one or another task, which, as a rule, led to imbalances in the effectiveness of the entire system.

In forming the main directions of development of the domestic system of higher education, one should apparently take into account the general trends in the development of civilization as well as the need to eliminate the shortcomings of the current system, and also preserve the best national traditions.

This article focuses on the system of higher education.

III. MODERN METHODS OF EDUCATION

There are five methods of practical training for students:

a) *Business games.* The method is based on organizing role-playing games through which participants represent their own interests in something and are faced with the need to make decisions. One of the main features of role-playing games is the development of communication skills, teamwork, development of thinking, ability to formulate thoughts and express decisions competently and clearly. This is a unique opportunity to use the knowledge gained in an imaginary situation while being in comfort.

b) *Situational method.* This technique allows to work out the so-called case assignments. This method will be perfectly combined with those sections of the disciplines where there is no unequivocal answer to the questions posed. The method focuses not on acquiring of knowledge, but on its development. This method allows to bring the solution of any problem to real life as close as possible. Students independently clarify the crux of the problem, determine their own position in a given situation, think through all the ways to solve the problem and form an answer.

c) *Project method.* In the twenty-first century, there is no way to refuse to use information technology. The basis of this method is the ability to navigate in the information space, also to contribute to the development of creative and critical thinking. The method focuses on the detailing of the problem which should have a solution with a practical result, obtaining specific information and an appropriate form.

d) *Testing.* The well-known and science-based method has already proved its worth and revealed both positive and negative sides. This method has several advantages such as:

- The opportunity for a short period of time to check a sufficiently large amount of material at the control test;
- The factor of the subjective approach to verification is excluded, since the test contains only an objective opinion. The same factor can be considered as a disadvantage in this method;
- The clarity and brevity of questions and answers to them are one of the positive factors as time on knowledge control can be saved when several answers have already been offered;
- -Tests can be of different options, but their plus is that they are on equal footing in terms of the composition of the question. There is a democratic approach;

Now, moving on to the disadvantages of this method:

The limitation in choosing the right answer does not allow the teacher to understand to what extent the studied material was learned and also to evaluate the student with a truly decent grade;

The limitation for the student in expressing his answer. Based on the previous paragraph, this method makes it impossible to express one's point of view and describe one's opinion and the solution to a problem or issue. Thereby, it is dulling the opinion of the younger generation and directing them to work on existing templates. This method deprives the country of specialists in the field of science and technology because of the "framework" created during the school years. The underdeveloped human thought is a lost innovation in various fields of science and technology.

e) *Terminological "Ping-pong".* As everyone knows, terminology is the main basis for any science, for the development of thinking, for use in production and for raising the level and elevation of one's own speech. Education, both primary, secondary, and higher, from any level begins with the study of terms. Each teacher is faced with such a problem as the control of knowledge in huge and not amenable to reduction volume. This method offers its own version of the verification of the studied terms. All terms necessary to be learned are defined on cards. Students can divide into pairs and choose cards. One of them names the term – the other says its definition and vice versa. It is possible to check knowledge of terminology in another way. This can be done in writing, so that the student could clearly state all the definitions and perhaps add some of his own examples. On the cards, several terms can be written and, one by one, handed out to students in order to ascertain the knowledge written on paper. This way it will be much more effective [3].

From the practical experience, it can be concluded that the knowledge enhanced during business games, discussions on various situations, project development, testing, etc. causes the least difficulty in preparation for tests and exams. To improve training more effectively, several methods suggested above can be combined.

IV. LEVELS AND APPROACHES

Innovative educational technologies in modern higher education are still being created. At the same time, some levels have begun to be distinguished:

a) *Modification.* This is an innovation of something that has already been created. The main features are the fundamental principles and technologies.

b) *Reproductive integration.* This level is based on the high qualification of the teacher, his experience and ideas. The bottom line is that the teacher creates his own new method of conducting a class by drawing on his knowledge of the material, the concept of the class and the existing methodologies. Through such convergence, a combinatorial innovation and an original system of lectures, practices and laboratory works appear.

c) *Creative integration.* The final level of innovational education system. The task of the teacher is not to inspire, but to direct a student to create something new. In the performance

of this level, a rather rare phenomenon in pedagogical practice – "radical innovations" – is used.

Perhaps it needs to be clarified that innovative teaching methods, unlike traditional ones, are those that stimulate the cognitive and creative activity of students. Based on this, they are called active learning methods. In this case, there are several types of activity that complement each other.

First, it is social activity. It is a detailed relationship of the individual and society as a whole. This is a fundamental activity, since the lack of the communication skills makes it almost impossible to settle in life. The next activity is cognitive. Cognitive, in turn, is divided into reproductive, interpretive, and creative. However, they all integrate the active state of a person, which is expressed in the manifestation of efforts and the mastery of knowledge. And finally, the third activity is activity in learning. Here, the teacher is required to organize the entire learning process, which contributes to the formation of student autonomy, responsibility, and a competent approach to solving the tasks set and the use of practical skills [4].

It should be recalled that innovative technologies as well as innovative education have been created on the basis of philosophical and psychological approaches. A learning model based thereon has emerged. This is the predominant method of student activity organized by the teacher.

a) This way behaviourism was created – a model of software training. In this model, reproductive learning plays a major role (relates mostly to traditional learning).

b) Constructivism is a cognitive learning. Here, the goal is to find a solution based on some kind of contradiction.

c) Theory of performance has already become a contextual learning, which is the development of knowledge in the work process.

d) The existential-humanistic approach is a student-centered learning. The main thing in this method is the dialogue between the student and the teacher. It is an exchange between people of different ages and categories, different cultural values, knowledge, skills and abilities [5].

Based on the above presented, such a classification is formed:

TABLE I. CLASSIFICATION OF APPROACHES IN EDUCATION

Model of education	Prevailing activity
Programmed education	Reproductive study (intermediate results monitoring and evaluation)
Intellectual development (cognitive strategies education)	Problem study (finding solutions)
Contextual education (mastering knowledge in practice)	Developmental study (knowledge + skills + competences)
Personality-oriented education (in culturological education paradigm)	Dialogue as a way of education

The main goal of teaching is to educate students in the essence and methods of the discipline, to develop a certain set of ideas and skills, an appropriate behaviour (do it in a right way and just in time on the first try), to provide motivation for

improvement (independent work). Goals should be realistic and achievable for a student, not interfere with the achievement of goals in other disciplines. Otherwise, they will not be perceived by them. A teacher and students are a single team working towards a common goal. Goals should be communicated to the student in a clear and precise manner.

Planning is the definition of the process of achieving goals over time using certain technologies. Technologies for achieving goals should be simple and understandable to students.

The organization of the learning process in time requires optimization. The 4-hour classes should be recognized as the most effective, allowing a student to focus, to combine theory and practice, not to disperse the energy of students and of a teacher [6].

V. PROBLEMS OF MODERN EDUCATION

Nowadays there are several problems of the internal environment of the university which have to be solved immediately. The first one is the routine nature of the education system. Now professors as well as teachers are flooded with paperwork. At the moment students spend less and less time than it took them 20 years ago. Students fade into the background in the work of the educational organization. The goal of such system is to ensure quality by checking every result. Twice a year, each student is checked for aptitude in the form of tests and exams. The part is expelled, the part is sent to make up for mistakes (to retake a test), the part is passed to the further stages of the educational process, with marks 3, 4 or 5.

The second problem of the internal environment of the university is that the teacher does not understand the role as a manager in relation to students and is not trained how to execute it. One of the definitions of management says: "Management is the ability to achieve the goals of the organization using the labour, intellect and motives of people." This formulation is perfectly suited for defining the tasks of a teacher who has been given the goal of educating a group of students in the essence and methods of a particular discipline that he teaches. For the duration of the educational process, the teacher becomes a manager who should turn students into an effective and focused group – a work team.

The third problem associated with the motivation of students could also be identified. Motivation is an important element of the success of the educational process. Unfortunately, this factor is poorly taken into account and analyzed [7].

It is obvious that in most cases there is a student who is poorly motivated to study the greater part of the disciplines of the curriculum and, moreover, to complete all kinds of tasks and projects on time. The teacher as the manager of the educational process needs to know the basic theories of motivation, ways to influence people, their strengths and weaknesses.

The main objective of a teacher is to involve students in the educational process, and not to force them to participate. Coercion and threats generate indifference and dissatisfaction, form low labour productivity, and unwillingness to learn at all. Studying is only a part of a student's life, not the whole life.

Student satisfaction with the educational process offers further positive and effective perception of the material being studied. Therefore, the teacher should know and understand the factors and the behaviour that students expect from him and which cause their positive perception of the educational process.

There are three groups of quality indicators that form customer satisfaction, including the student – with the quality of the product (educational services): 1) basic, 2) expected, 3) admirable. If the basic indicators are formed mainly by the course program and the teacher's knowledge of a particular discipline, the expected and admirable ones are formed by the teacher's personality, the ability to interest students and involve them in the educational process. The last two groups of indicators are the most important in order to form a positive perception of the discipline, its usefulness and importance for the future and for the formation of the student as a specialist. The results of research on this issue using statistical quality tools show that the teacher is the main character of the educational process for the student [8].

Control is an integral part of any kind of work, since used to assess the correctness of the development process and its movement in the direction of the goals. Control should help to reveal the causes of inefficiencies, and not just be a way to detect mistakes and punish those responsible. Control is, first of all, feedback for the development of remedial actions. The control data have to answer the question whether students perceive and understand the material that is being taught. If this is not the case, then remedial actions should be taken urgently to improve the teaching process. It should be remembered that teaching is the process input, and learning is its result (output). Control is needed in order to constantly monitor and adjust teaching based on learning outcomes data.

Continuous control with a perspective to the learning process progressing (monitoring) and timely remedial actions are the components of educational process management. If there has been no management, then the resulting control becomes unpredictable and largely ineffective: it determines only what the student has been able to perceive with the passive role of the teacher. If the management has been effective, then increased grades prevail in the group and high satisfaction with the discipline is formed.

Communication, or information sharing, is the main tool of the teacher. The teacher has to reach flawless mastery at it. He should be able to listen to students, take into account their wishes, and help to understand the discipline being studied. Without effective exchange of information, the student cannot learn anything [9].

VI. CRISIS OF MODERN EDUCATION AND WAY OUT OF IT

Recently, problems that cannot be solved within the framework of educational reforms are being actively manifested, and, therefore, the global crisis of education is increasingly being mentioned. The statement of the crisis of education has moved from scientific literature to official documents and comments of statesmen who note that the essence of higher education turned out to be reduced to the education of narrow specialists; its goal has become not the

holistic development of a man, but only of some of his abilities that correspond to the division of labour.

Vocational education is not able to adequately solve the problem of "personnel hunger" caused by new requirements to the level of qualifications of specialists. In our country, the education crisis has a dual nature: on the one hand, it is a manifestation of the global crisis, and on the other hand – the result of the process of modernization of the Russian education system.

Large corporations more often attempt to create their own business schools, educational programs, personnel reserves, and engineers training programs. The list of tasks for the development of engineering education is successfully solved by state corporations. For example, the state corporation ROSATOM implements the project "School ROSATOM", the aim of which is to keep enterprises and state corporations of a high educational level in the cities. It provides for annual competitions for teachers and managers at a professional level and support systems for the development of talented children. ROSTECH develops projects related to the cooperation of the leading universities of the country, their interconnection in order to create educational programs, including the "integration of education, science and production" – joint work with universities to implement contractual training of engineers and improve the level of training. The work of the Ministry of Education and Science of Russia is not left aside and it allows to solve many problems of the development of engineering education [10].

The transition to a lifelong continuous learning system and the idea of lifelong education has a definite goal which is not the development of the inner world of the individual, but its success in the labour market. The gap between those who succeed in the labour market constantly maintaining and updating their skills and those who are hopelessly lagging behind, not keeping pace with rapidly growing professional requirements is constantly growing. The main priority of society is not a person, but an economy that requires competitive human resources for its development; in sum, these changes can be described as a transition to a world based on knowledge, or to an informational world, where the basis of the economy is intangible goods and services and where knowledge, skills, and competences become of paramount importance.

Consider the international experience in solving problems of engineering education. In many countries, there is a two-step system of quality requirements for engineering training and validation of engineering qualifications. The first stage is the training of specialists who have completed an undergraduate educational program in the branches of engineering and technology that have been accredited. The second step is to confirm the professional qualifications of engineers through certification.

Foreign countries are rapidly changing their education system. Students focus more on practical activities, trying to immediately study how to think logically on the basis of the production process [11].

The engineer of the XXI century should be:

- competitive;
- "modern" – to be aware of the discoveries of new technologies and current issues and analyze their solutions;
- should possess multimedia and information knowledge, skills, competences;
- innovation and management active;
- should create technologies not only for production, but also for domestic use.

Since 1999, the modernization of vocational education has been going on in Europe. Their systems are based on regulatory and legal acts, reasoned by the Bologna process. This system would allow European citizens to freely choose their place of study, work, and even a country. This provides for optimal employment of graduates of any university.

In the opinion of members of the Board of Trustees, the following measures can lead to the high competitiveness of Russian higher education: to combine the educational and research work of students with the orders from industrial enterprises, to prepare specialists for specific firms, to determine the amount of state financing of the education system adequate to modern requirements, as a percentage of GDP, to attract successful industrial enterprises to finance higher education through educational funds and loans, to organize an intensive exchange of students, graduate students, and teachers with leading Western universities; the same number of members of the Board of Trustees believe that Russian education has proved its competitiveness by "brain drain" to the West, it should follow its previous course, without taking into account the requirements of the Bologna Convention.

VII. CONCLUSION

The introduction of such reforms in Russia was not limited to a positive impact on the education system and created new problems. Therefore, despite all the problems due to changes in education, Russia has to raise its prestige among engineering specialties. An engineer has to be simultaneously a scientist, a technical and technological specialist, and a manager of industrial production.

Thus, in the modern development of the institute of higher education, there is an ever accelerating process of accumulation of contradictions. The gradual restructuring of the education

system already goes beyond the framework of the institute of education and affects the fundamental bases of the development of society.

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