Problems and Peculiar Aspects of Training of the Future Engineers in Relation to Higher Education System Remodelling

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Abstract. The article attempts to analyze the current situation with University education, proposes a model of a modern University and training of engineers.

1. Introduction

Higher engineering education, same as humanities and teacher education in Russia is currently suffering certain indefiniteness. On the one hand strive for enabling the remodeling of the higher education made us try all the existing Western practices related to organization of training process for the future engineers, to the extent of coming of MIT professors to Skoltech, and various futurologists keep saying that the next 15 years shall see a fundamental change in education effected by digital technologies and the coming industrial revolution [1]. On the other hand business, particularly iron and steel making companies point out that existing professional training is insufficient in terms of challenging the current industrial tasks, that Universities are out of touch with industrial production, that remodeling is a critical issue of today. Still neither business, nor futurologists can indicate the exact ways to make the present training of engineers at the University meet the necessities and realities of the day.

2. Problematics

Yes, indeed we need to confess that higher engineering education is facing the hard times. Here are some problems of the modern Universities which assist cultivating their existing image in the eyes of business:

1. Mass nature of higher education. The Universities are no longer postured in the society as a place for upbringing the future elite, but merely represent a place for rendering educational services to those who have completed 11 grades in order to get the University diploma afterwards.

2. The second reason resulting from the first mentioned above – motivation of University applicants and students. I know from my own experience of work at the University that the portion of motivated students (those who realize what people expect from them and what they need to do at the University) makes about 10-20% from the total number of students. Most of the University students if I may say so «simplify their study on their way to get a document certifying their qualification to the maximum extent».

Half of those students are enrolled to the University by chance, but this is not the reason. This is caused by the existing training formats (see par. 3 below).
3. The existing training formats. Lecturing, narrating of the textbooks contents to the students, courses with unclear intention in terms of competency map forming taken by students – all that being rendered over 4 years of bachelor’s degree course and 2 years of master degree course brings down the interest of students in their study. The information available in the network replaces the teacher as a knowledge translator. Educational programs are mostly not flexible, suggesting merely formal selection of elective courses. One can compare a typical University pathway with a pipe: on one end you enter the University training program, on the other end you come out with a document certifying your higher education. Training programs are designed to cover the competencies of the existing academic staff instead of competencies of the future specialists required by business. In this regard what underlies training is the maxim «We teach you what we know, but not what you need».

The existing educational formats facilitate established opinion that University study is a waste of time, which can be proved by the latest statistics for reduction of popularity of the Universities among the school children.

4. Presence of inertia while training the human resources with higher education in the existing educational system «bachelor’s degree – master’s degree» does not allow for prompt response for the business requirements. Remodeling and upgrading of educational programs under these conditions may give its effect at least after the period of 2-4 years.

5. Certain asociality of «educational eco-systems» in domestic Universities. This proves to be one of the key aspects which differs Russian education from West European or American one. For about 20 years already the Universities in the USA and Western Europe have developed and adopted interactive means of training, control, organization and implementation of education and research processes based on Internet technologies, the main objective of which is on-line cooperation, access of the students to big data and creation of a global community with network education based at the best competencies of the leading global Universities [2, 3].

This issue of educational eco-systems’ asociality, development and adoption of Internet technologies and artificial intelligence in the system of education is currently being dealt with by a project of National Technology Initiative (NTI).

All the indicated and other existing problems as well as realizing that “something is wrong” with the higher education lately have brought forth many discussions in professional society related to the topics so popular today: digital transformation at the Universities, project activity in higher education, soft or hard skills, professions and competencies of the future, big data, individual nature of education etc.

However in chase of those popular trends such discussions sometimes bring to life theses dangerous for business development, for example:

- «future belongs to online education»: it is absolutely clear that none of potential employers in the sphere of engineering would like to hire specialists trained in a remote manner;
- «bachelor’s degree course does not cover training for qualification, rather some initial general degree of higher education and development of personality».

The situation mentioned above makes businessmen and industry-related people concern about personality and methods of training the future motivated professionals and experts with basic knowledge, able to design technologies and equipment, to bring up innovations facilitating development of industrial companies in various spheres; another issue that arises in this regard is the real mission and role of the Universities in training of professional personnel for industrial and research activities.

3. Peculiarity of the University-based education

The fundamental distinction between University-based education and that of the secondary school or secondary professional education organizations is the research process.

Research shall «penetrate» all the educational activities at the Universities (Figure 1), meaning that it is vitally important to engage Academic staff dealing with active research and expertise in their sphere to the educational process. Here however lies one unsettled discrepancy between business and
University-based training: if a researcher teaches a student what he knows himself, then he shall lose his unique competence, which is a real threat for his position at the University. That’s why the University-based training shall be founded on creating of environment for independent / team research work and acquiring of new knowledge instead of drilling. Thus together with research process, creation of new knowledge instead of their repeating at the University is the second key distinctive feature of the University from other types of educational institutions.

Absence of true research activities at the University and respectively new knowledge results in a sort of discord and failure to understand the processes going at the University for eventual consumers. Without research and researchers the University becomes more like a mere secondary school, or a college; in this situation it is hard for Universities to identify themselves at the labor market as an entity able to present the results of educational process as a certain set of competencies with its graduates.

Decaying of higher education in this respect is also noted by the management of the Russian Academy of Sciences, as lately they have observed shortage of young specialists bearing quality competencies of researchers and developers.

With regard to multiple training programs at the Universities which cover more than just engineering, digital, economic and humanistic aspects the educational programs based on interdisciplinary research are relevant today [4, 5]. For instance, this can be related to programs intended for estimation of social effects from technological innovations, studying of society via social networks using analyses of big data, enhancing of industrial safety at the production plants using digital analysis of personality.

Taking into account the aforesaid, it isn’t the study of individual disciplines that educational process at the University shall begin with, but rather crossdisciplinary problematization which definitely requires development of a certain model.

4. Model of University-based education
Development of a model of the University educational process based on research shall rest upon understanding of results intended to be reached. Such a result should be the competencies of the graduates. In their studies [6-11] the authors tried to write such a competence-based model for training of engineers apt for the present-day iron and steel-making industry, as the industrial business of today is searching for certain competencies (skills and abilities to do).

The general concept of a model for the University-based training of engineers is shown in Figure 2.

Figure 1. Scheme of University-based training.
Figure 2. Components of the University-based educational program for engineers.

The very essence of all the engineering training programs shall be aimed at development of competencies in the sphere of designing, modeling of objects and systems, as well as description of such processes by programming languages, for which purpose it is necessary to count for a module of courses related to information technologies including data analyses and processing, skills on CAD- and CAE-systems operation.

The socio-humanistic module is required for analyses of research problematics in the aspects of history and philosophy, identifying of competencies for estimation of the social effect rendered by research and innovations, as well as activities on identifying the talents, leadership qualities and team building necessary for project activities implementation.

Training programs shall be flexible so that to enable the students to select among the courses at various levels: general University level, at the faculty, at the subdepartment. Realization of this module secures that a student can by himself map out his path in education, get certain competencies in his professional specialization, get acquainted with outstanding professors and prominent projects of the University, solve engineering and research tasks at the interdisciplinary level.

5. Conclusion and Summary
Now therefore notwithstanding the opinion of multiple experts on decaying of the higher school in Russia and its redesigning in the view of the fourth global industrial revolution (industry 4.0), we still understand that it is necessary to retain the best practices, education formats and develop engineering education which can enable training of new specialists at the level able to meet requirements of the leading industrial companies.

As for the Universities, it is obvious that in order to preserve the Universities in the light of development of distance on-line education formats, it will take researchers to teach but not teachers to get into science. People at the Universities must generate new knowledge, still the transit able to balance creation of new knowledge and their adoption for technology is quite relevant.

To render its maximum functionality the Universities shall be based on three main aspects: students, researchers and infrastructure (Figure 3).
In the process of research activities at the University innovations shall not be separated between the engineering sciences and the humanities, as all the modern science and its results rest on the junction of various fields which enables evolving of new fields in science, making the science change. Research agenda is crucially important at the University since it allows for making a step to those who may «influence» the processes in the region, in the country, in the world (Figure 4).

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