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## Institute of Engineering, Technology and Technical Sciences for New Industry

Ural Federal University named after the first President of Russia B.N. Yeltsyn  
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The present paper considers the Institute of Engineering, Technology and Technical Sciences as an efficient model of university structure to provide engineering education of a new format [1] and develop the education programmes for the next generation engineering and technical personnel [2], [3], [4], [5]. The effects of the model implementation at universities have been described.

**Key words:** new format of engineering education, master of engineering degree programme, bachelor of universal engineering degree programme, integrated programmes, organization structures, engineering and technical personnel.

### Introduction

Most industrial sectors in Russia suffer from lower labour capacity (compared to that in developed countries), dependence on import in various forms and to varying degrees, industrial backwardness, and as a result, competitive disadvantage of national production. The situation is getting worse due to the rapid pace of technological advancement and the forth industrial revolution, which humankind is facing today. Industry 4.0 introduces a new level of robotic automation in manufacturing and widely implemented adaptive digital technologies. The reality of today is self-adjust industrial automation systems, collaborative robots, bionics, digital production process, and other technical innovations. To remain economically independent, the country has to get into this process through enhancing today's national production, but to make a technological breakthrough and implement cutting-edge industrial technologies is most important.

New industry requires new personnel. Today's engineers should be ready to cope with complex technological processes and equipment, adapt to changing requirements for product competitive advantages, be able to find non-standard and even revolutionary solutions, accomplish an

intellectual feat. In fact, it should be a new generation of engineers who can combine research, project management, engineering, and economic competencies, which should be acquired while studying at universities and then improved through life.

The particularities of modern technical education system at the stage of transition from large output of engineers to three cycles of higher education qualifications are conceptually-indefinite first cycle of bachelor's degree and bias in research at the second cycle (master's degree).

As a result, reduced study time hinders engineering education at the first cycle, while master education programme fails to be oriented to manufacturing and technological activities. Therefore, there is a deficiency of engineering staff, who correspond to the 7th level of National Qualifications Framework, are able to become leaders of national reindustrialization and creators of new competitive technologies.

However, it would be naive to expect that the technical education system established over several decades can undergo large-scale changes [4], [5], [6].

An efficient way to overcome the challenges is green field development,

when those who step up efforts to design new education models do not have to spend them against the resistance of conventional schemes and approaches.

To bring up the next generation of engineers capable of beating back the challenges of the 21st century, it is necessary to introduce new administrative mechanisms in institutes providing engineering education of a new format [9], [10].

One of the ways to solve the problem is to develop a polytechnic network, which will allow involving resources of the industry partners, as well as attracting best experts and university teachers from all over the world.

### Institute of Engineering, Technology and Technical Sciences

The aim of the Institute is further development and synergy of scientific and educational achievements in engineering, technologies, and technical sciences.

The objectives of the Institute are as follows:

1. Scientific and technical production based on the achievements in the important and promising fields and attraction of partners from leading Russian and international scientific and technical centers. Creation of a new interdisciplinary trend in scientific and technical research.

2. Development and implementation of Elite Engineering Bachelor's Degree Programmes (3-4 years), Master's Degree Programmes in Science and Engineering, as well as postgraduate programmes to train highly-qualified personnel.

3. Development of the Institute as a model of education, science and innovation management, with synergetic effects from uniting the best.

One of the Institute's distinguishing features is networking: it is of primary importance to develop integrated continuing (in terms of outcomes and levels) education programmes.

### Model Structure of the Institute

In terms of its structure, the Institute includes scientific laboratories, as well as

scientific and technical personnel, selected through competition and having relevant scientific and technical achievements in priority manufacturing sectors. Together they make up a cluster, which is conventionally named the Academy of Technology and Technical Sciences. The main objective is scientific and technical production (research and development works, publications, involvement of the best Russian and foreign professionals in co-design).

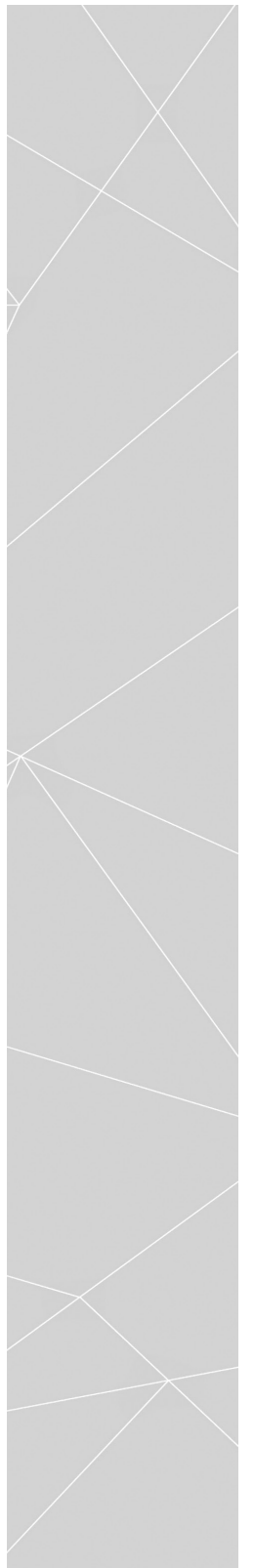
The Academy provides Master's Degree Programme in Science and Engineering and postgraduate programme in compliance with the scheme 2+4.

The Institute also includes School of Higher Engineering Education, which provides Engineering (Technical) Master's Degree Programme aimed to develop qualifications (competencies) necessary to perform engineering activities, i.e. creating engineering products, systems, and technologies. The programmes can be oriented to satisfy the demand of partner manufacturing enterprises and labour market in general, as well as to graduate "innovative engineers", who can contribute to innovative processes at companies and research centers, to implement their own pilot projects.

Some modules of Engineering Master's Degree Programme may be used as a basis for developing additional professional education programmes. In its turn, realization of these short-term programmes will result in continuous updating and improvement of the basic master's degree programme.

School of Higher Engineering Education is to provide methodological support for development and implementation of education programmes in Engineering, Technology and Technical Sciences in compliance with the best international practices and at all education levels (Bachelor's degree – Master's degree – postgraduate courses) under the auspices of the new Institute.

The structural basis is the Institute of



Fundamental Education, which provides the unified educational courses in compliance with the state specialty and professional classification for technical specialties within 1-2 years of studies (120 credits). The students acquire knowledge in mathematics, natural sciences, and general engineering.

Educational process management is performed by education program supervisors, who provide the whole cycle of engineers training. Together, these supervisors compose the Directorate for Engineering Education. The programme supervisor is responsible for student selection, network interaction maintenance, student academic mobility and their involvement in competition and project activities.

An important component of the Institute infrastructure is student self-organization, i.e. student clubs, constructive bureaus, etc.

The educational project particularities are project-based learning [11], [12], [13] and individual educational technologies, which imply different levels of study (different learning outcomes) and various ways of study, including online courses. Free online courses make it possible to study some disciplines even before entering the university, ensure continuous study for the student of vocational training colleges and technical schools, and provide network programmes for the students in other universities.

Within the module "Engineering Fundamentals" (taught instead of the traditional one "Fundamentals of Specialty"), students get exposure to engineering and work in team engineering activities within the CDIO educational framework implemented for producing the next generation of engineers. Based on the student ranking performed at this stage, educational paths are determined, including the type and academic major of the educational programme.

Another component of the Institute structure is School for Bachelors in

Engineering. Students can be enrolled in the School after two years of study at the Institute of Fundamental Education and are selected through a competition. The School graduates are Bachelors of Engineering meeting the particular employer skill demands. As for best-trained and most motivated graduates, they can be enrolled in different Master's degree programmes.

Bachelor of universal engineering degree programme provides many opportunities: besides technical competencies, the graduates can get profound knowledge in economics, management, and law, as well as develop additional competencies, such as foreign language or information technology skills. Any student has an opportunity to select an educational path, which will be the most adequate to develop additional competencies and thus improve the graduate's competitiveness on the labour market. If a graduate decides to continue education, he or she will also have a wider range of Master's degree programmes to choose from.

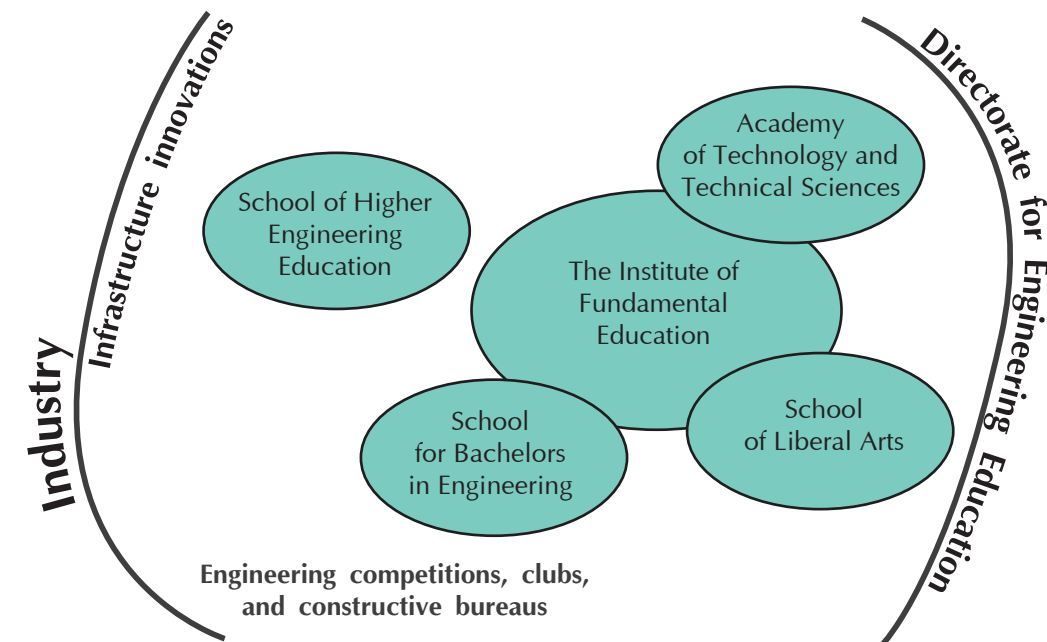
This is so called Liberal Arts model, which will be implemented at the School of Liberal Arts (Fig. 1).

The whole cycle of higher engineering education based on interdisciplinarity and educational programme integrity is provided by the following organizations:

- Academy of Technology and Technical Sciences.
- School of Higher Engineering Education.
- School for Bachelors in Engineering.
- School of Liberal Arts.
- The Institute of Fundamental Education.
- Directorate for Engineering Education.

The objectives of the Institute are supposed to be reached involving the resources of innovative infrastructures to train engineers-researchers, who will design and develop a "smart world", including "smart networks", "internet of things", additive technologies, robotics, artificial intelligence, transport of future, etc.

Fig. 1. Institute of Engineering, Technology and Technical Sciences



The model of the Institute described above can work as a separate entity or be integrated into the structure of large polytechnic universities. The major condition for the Institute to be established and developed is the development of the region industry.

The model components can be used in different variations in various university environments, however, the whole model ensures the maximum efficiency.

The effects of the model implementation are as follows:

- Engineering Master's Degree Programme substitutes Specialist's Degree Programme and allows improving graduates' competitive advantages.
- Master's Degree Programme and post-graduate programme are interconnected since two years of study are not enough to train an engineer-researcher, who is capable of using the latest achievements of both fundamental and applied

sciences to create new products in demand.

- Engineering clubs, constructive bureaus, and competitions allow selecting the most motivated, smartest and determined applicants with high level of self-organization, as well as help to choose the appropriate educational path (scientific and research, entrepreneurship, etc.).
- Specified learning outcomes (engineer's competencies), project-based learning (including engineering competitions), industrial internship provided by the relevant entities (departments, continuing professional development centers) ensure that industrial enterprises participate in the educational process and minimize enterprises' costs for personnel education [14], [15].
- Implemented by the Directorate for Engineering Education, education programmes are independent from the department or institute administration. Network and interdisciplinary

programmes are widely implemented. Education programme supervisors are interested in collaboration with

industrial partners to implement practice-oriented learning, hand-on activities and practical tasks solving.

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