Analysis of the modern science and technology in the context of the concept of CDIO

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Abstract. The paper presents modern trends in science and technology of the beginning of the 21st century and the response of engineering education to the current needs of society. The analysis of publications is made, in which methodological approaches are presented in the design of innovations in science and technology. The opinions of the regional engineering community of the agrarian sector and the sphere of IT-technologies are studied regarding the possibilities of implementing CDIO standards in programs for the training of professional engineers. The comparative analysis of opinions about the ideal attributes of the future engineers expressed by the engineering community, it is significantly differing in character and objects of professional activity and they made it possible to speak on the example of practical industrial activity about the manifestation of general trends in the development of science and technology. There remains a need for understanding innovative trends in engineering activity articulated both at the level of the global scientific community and at the level of regional engineering practice.

1. Introduction

Modern world trends in science and technology of the early 21st century are associated with the acceleration of the growth of scientific knowledge (the amount of processed information, the volume of scientific product); interdependent tendencies of differentiation and integration of scientific and technical areas (the emergence of the "frontier" sciences at the intersection of knowledge and the need to synthesize sciences and scientific disciplines with their research tools, the emergence of interdisciplinary areas); digitalization of scientific knowledge. [1–4] Under these conditions, it is important to keep the connection of scientific and technical innovations with everyday professional engineering practices. The modern engineering community must fully meet these challenges: possess sufficient breadth of professional engineering horizons for successful implementation of work in search engines, knowledge in related technical fields, possession of digital technologies, technological training with the basics of economic knowledge about the product life cycle, and social and environmental responsibility of the specialist and the head of the production team. [5, 6] For engineering education, which during the design of educational programs should meet the challenges of modern trends in science and technology, the issue of introducing the international initiative CDIO to modernize basic
engineering education based on a universal model of the entire product life cycle: idea, design, implementation, management is being updated. It is this approach that significantly reduces the gap between the theory and practice of engineering activity and allows modern production and education to constructively interact supporting key trends in science and technology.

2. Materials and methods
The research methods are the analysis of scientific publications on the development of modern science and technology and the synthesis of ideas from specialists from the engineering services of successful agricultural and IT enterprises in the region about possible engineer models in demand in the regional labour market in accordance with the CDIO. A total of 119 people took part in the expert survey, including: 53 IT experts and 66 agrarian experts - heads of engineering services and leading engineers of enterprises and organizations of the Stavropol Territory. The relevance of the representation of experts on the areas of production activity is due, on the one hand, to the active development of digitalization in the region, on the other hand, a significant share of agricultural production in the region.

The engineers and research participants were asked to highlight important attributes for successful engineering activity in modern conditions of science and technology development based on CDIO Syllabus, which are informatively described in 4 information sections: disciplinary knowledge and fundamentals; professional competencies and personal qualities; interpersonal skills: teamwork and communication; planning, design, production and use of products (systems) in the context of the enterprise, society and the environment.

The data was collected in 2018 and processed in the SPSS program (version 23).

3. Literature review
The need to understand the general trends of science and technology and to ensure continuity at the level of the process of training engineering personnel is indicated by the authors of the publication “Engineering curriculum development based on education theories” (Prasad J., Goswami A., Kumbhani B. et.al.). The engineering programs of the Indian Institute of Technology are complemented by the philosophical and social context of future professional activities, in which there is a close relationship with society, practical training, creativity and innovation. [7]

The growth of the volume of scientific developments, the increasing complexity of the systems of scientific knowledge and practice actualize the issues of improving approaches to diagnosing and managing complex objects. The authors Mittal S., Diallo S., Tolk A. in the book “Emerging Behavior in Complex Systems Engineering: A Modeling and Simulation Approach” [8] offer an up-to-date resource for designing, developing, managing, operating and maintaining complex systems. New approaches and methods of modeling and simulation make it possible in engineering practice to predict the effectiveness of the introduced innovations and to avoid the dangers of unforeseen consequences. In the general approaches of the worldwide engineering initiative CDIO much attention is paid for it and a whole content module of standards is devoted. [9–11]

The issues of improving the quality of practical skills of engineers and their ability to innovate are touched upon in their scientific publication “Research on the innovative engineer” by Li Y., Li Z., Ren Q. [12]. Building up not only practical experience, but also the comprehension of engineering activity is today a condition for the preparation of a competitive engineering specialist.

The increase in the volume of innovations actualizes ethical issues related to the norms and values of modern society. Thompson P.B. in the publication “The roles of ethics in gene drive research and governance”, it proposes to increase attention to the research of ethical results of innovations on the example of a separate sphere. In general, this position of the author is reflected in the approaches of the worldwide engineering initiative CDIO, which are implemented in the process of preparing modern engineering personnel. [13]

Important approaches to the assessment and understanding of modern trends in science and technology are outlined in the scientific work of scientists Verschraegen G., Vandermoere F., Braeckmans L., Seguert B. "Imagined Futures in Science, Technology and Society" [14, 15]. The book
presents the author's vision of an interdisciplinary assessment of the influence of scientific and technological imagination on the formation of the ecological and social future of humanity. This position once again underlines the importance of social and ethical responsibility in the planning and implementation of innovation activities.

Thus, summing up the discussion of existing trends in science and technology through the prism of CDIO approaches, it can be said that the world engineering initiative responds to the key challenges of modern engineering practices.

4. Results of the study of the views of the regional engineering community of the agrarian sector and the sphere of IT-technologies

The results of the study of the views of the regional engineering community of the agrarian sector and the sphere of IT-technologies regarding the possibilities of implementing CDIO standards in the specialist training program for engineers showed a more significant value of the disciplinary bases and professional competences for the production agrarian sector. Whereas for the representatives of the engineering community in the field of IT-technologies, interpersonal skills are a priority such as teamwork and communication; planning, design, production and use of products (systems) in the context of the enterprise, society and the environment. The data are presented in Figure 1. The evaluation was carried out in points on a ten-point scale.

![Figure 1](image-url)

**Figure 1.** Comparative estimates of the significance of the engineering qualities of a specialist (average score on a ten-point scale)

A more detailed substantive examination shows that the requirements of modern production equipment and technologies will be impossible for an engineer if he does not possess a high level of the following competencies:

- for specialists of the agrarian sector: system thinking (9.3 points); demonstration of engineering entrepreneurship skills (9.3 points); in-depth knowledge of the fundamentals of engineering, methods and tools (9.2 points); readiness for operation of production machines, process equipment and systems (9.1 points); understanding the role and responsibility of an engineer and the ability to manage a team (9.0 points); the ability to use modern methods of installation, commissioning of machines and installations (9.0 points);

- for IT specialists: development of an entrepreneurial and business context of engineering activity (9.3 points); assessment of the impact of engineering activities on society and the environment (9.2 points); key knowledge of engineering fundamentals (9.1 points); knowledge of the main vectors of
global perspectives (9.0 points).

Thus, it can be seen in the priorities of an important functionality of engineers demanded by modern agricultural production and IT-sphere customer orientation, i.e. practical applications of any innovations. With the growing needs of modern society and the growing differentiation of needs, key trends in the development of science and technology are being confirmed - an increase in the volume of a scientific product, accompanied by substantively interdependent trends of differentiation and integration of scientific and technical trends and the digitalization of knowledge.

5. Conclusion

A brief overview of existing trends in science and technology through the prism of CDIO approaches and the experience of practical engineers leads to the conclusion that the global engineering initiative responds to the key challenges of modern engineering practices and it is consistent with the modern innovative trends and technologies.

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