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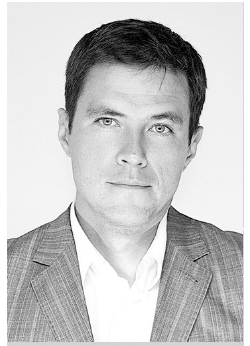
Implementing CDIO Initiative in Russian Universities: Interim Results and Prospects



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Abstract

The paper describes interim results of implementing the CDIO initiative into education programmes of national universities. The author has indicated the trends in publishing academic papers on the topic. The factors hindering CDIO implementation into national education have been identified. The author gives recommendations and suggests the algorithm for implementing CDIO into the education programme of the Russian university.

Key words: training, engineering education, technical specialties, CDIO, education standards, publications.

Introduction

The future of the Russian society and national economy strongly depends on enhancements in the sphere of national education. Engineering training seems to be particularly important since the new technological era makes it necessary to revise the concept of engineering education. The RF is not the first one to face this challenge, and one of the solutions suggested at the turn of the 21st century was the CDIO Initiative, the idea developed in cooperation between Massachusetts Institute of Technology and several European universities. In the RF, the Initiative was adapted and adopted by a number of educational institutions in 2013, and over the past four years another ten universities have joined CDIO. However, no one has made an attempt to consolidate the efforts of researchers, professionals, and teachers interested in CDIO and to determine the prospects and trends of the CDIO Initiative development within the scope of the national education.

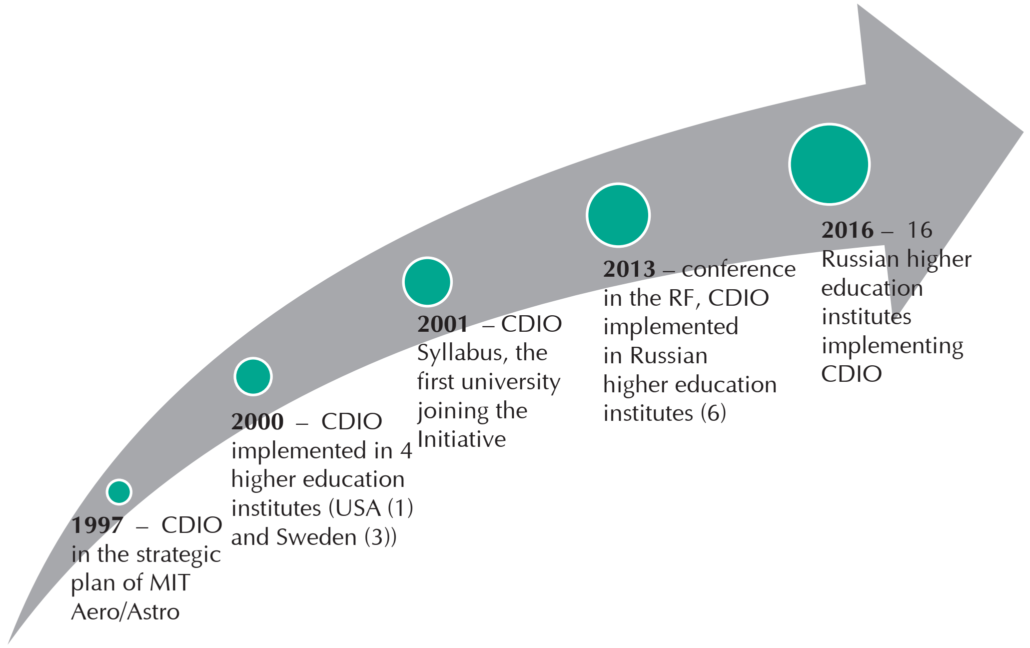
This is what the present paper deals with: the author analyses the interest in CDIO reflected in scientific publications, interprets the content, and determines the trends in CDIO development and implementation into the national education system.

CDIO in scientific publications: trends and priorities

The challenges within the system of higher education, and engineering higher education in particular, are an urgent issue for scientists, and many new approaches are currently suggested. One of them is the CDIO Initiative, an innovative multifaceted approach to engineering education, formulated as an idea in 1997 and then designed and implemented in 2001 in cooperation between Massachusetts Institute of technology (the USA) and universities of Sweden. The course of the events is given in fig. 1.

First publications on CDIO in Scopus are dated by 2002 and the topic has been gaining interest since then. In 2016, the annual number of Scopus publications dealing somehow with CDIO was six times as much as that in 2002: 5 and 30 publications, respectively (fig. 2).

Fig. 1. CDIO development on the global and national scales (the RF)



The number of publications in national journals has also increased (see the trend in eLIBRARY.ru given in fig.2). It is noteworthy that Russian scholars tended to be more interested in the topic than the foreign ones (in 2014, 112 publications in Russian Science Citation Index (RSCI) database compared to 54 publications in Scopus). The first article in Russian devoted to CDIO was published in 2011, and the interest to the topic reached its peak in 2014, when the journal Engineering Education published the issue focused on CDIO.

With the number of publications on CDIO topic increasing, it is possible to identify particular trends in the researchers' interest. However, one can notice that the majority of papers are published in conference proceedings rather than in scholarly editions: out of the total number of publications on CDIO in Scopus (410), there are 93 journal articles, 14 book chapters and paragraphs, and 286 proceeding papers.

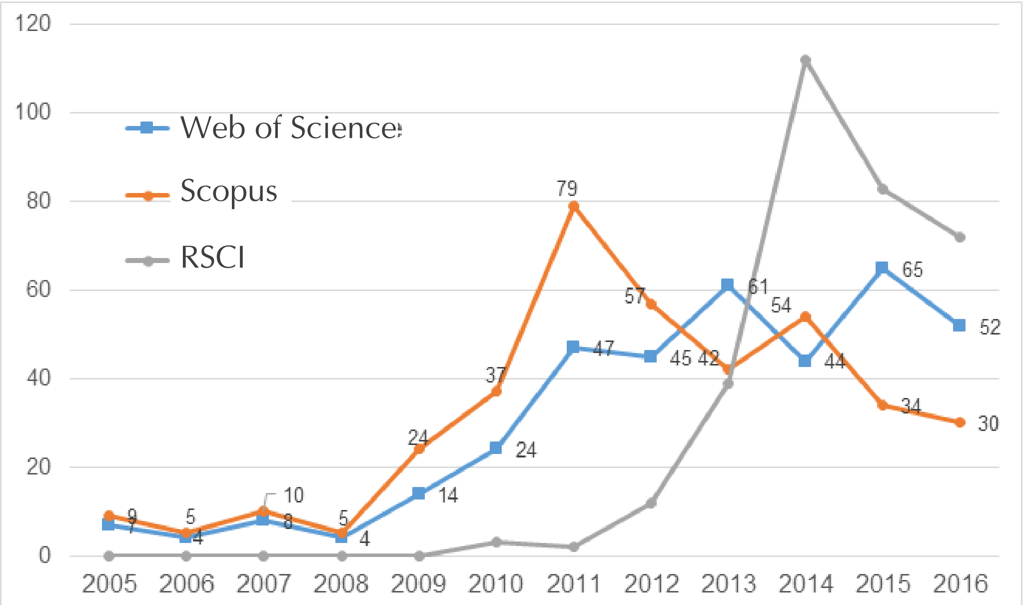
The analysis of publication activities carried out within the scope of the present research has shown that over the past 10 years the number of publications on CDIO had slightly decreased and reached a plateau (Scopus, Web of Science, and RSCI) (fig. 1). The research material included articles and conference proceedings published between 2000 and 2016, in which CDIO is used in the title, abstract and/or key words.

First appeared in more recent times, the interest to CDIO peaked in 2011–2013 (in foreign countries) and in 2013–2014 (in Russia), and then the number of publications became steady.

To identify the key trends within the scope of CDIO research, we have analyzed the content of the most cited (Scopus and RSCI) and most recently published papers. The publications were selected based on the term "CDIO" mentioned in the title. Over the period of 2000–2016, the number of publications in Scopus equals to 93. Table 1 presents a list of journals, in which the majority of papers on CDIO were published.

The most cited papers are those by Crawley, E.F., Brodeur, D.R., Soderholm, D.H. (2008) [1], Edstrum, K., Kolmos, A. (2014) [2], Lunev, A., Petrova, I., Zaripova,

Fig. 2. Publications on CDIO topic in Scopus, Web of Science, and RSCI



V. (2013) [3], Woollacott, L.C. (2009) [4], Padfield, G.D. (2006) [5], and Wang, Y., Qi, Z., Li, Z., Zhang, L. (2011) [6].

Among the papers published in Russian, the most cited are those by Gafurova N.V., Osipova S.I. (2013) [7], Chuchalin A.I. (2011) [8], Yakovlev A.N., Kostikov K.S., Martyushev N.V., Shepotenko N.A., Falkovich Yu.V. (2012) г. [9], Zamyatina O.M., Mozgaleva P. I. (2013) [10], Mineva O.K., Akmaeva R.I., Usacheva L.V. (2013) [11], Treshchev A.M., Sergeeva O.A. (2012) [12].

These papers deal with implementing CDIO into metallurgical engineering education, teaching mathematics for engineering students, stakeholders' expectations for proficiency based on CDIO standards implementation CDIO [13, 14].

Having analyzed the bulk of papers on CDIO Initiative (most cited and most recently published), one can drive to the conclusions as follows:

- the majority of papers are case studies dealing with CDIO implementation into the education programme; this proves the fact that the CDIO concept is to be clearly comprehended, interpreted, and consolidated;
- the research is conducted in leading engineering schools in China (41 publications in Scopus), the USA (8 publications), Russia (6 publications), and Sweden (6 publications);
- among the most cited papers, the only one belongs to the Russian scholars; however, it is clear that the experience of enhancing the system of engineering education in Russia should be further studied and transmitted throughout the global scientific community.

Table 1. Journals publishing academic papers on CDIO

Journal	Number of articles on CDIO
World Transactions on Engineering and Technology Education	18
European Journal of Engineering Education	5
Journal of Engineering Science and Technology	5
Australasian Journal of Engineering Education	4
Energy Education Science and Technology Part a Energy Science and Research	4

Let us analyze the CDIO approach in detail and identify the main trends in implementing CDIO in national engineering institutes.

The CDIO concept for engineering education

According to the definition of its designers, the CDIO Initiative is a multifaceted approach to engineering education (in particular, bachelor's degree programmes), which includes the key principles of programme design, material and technical support, staff recruitment and continuing professional development. The CDIO abbreviation comes from the key concepts: Conceive – Design – Implement – Operate. Therefore, CDIO is a complex framework for training engineers able to generate ideas, design, operate, and dispose engineering products [13]. The CDIO aim is to graduate an engineer who can create a new product or an idea, and then design and implement it.

In their paper, S.A. Podlesny and A.V. Kozlov mention that one of the challenges in CDIO implementation in Russia is the lack of laboratory equipment to conduct experiments and the lack of opportunities to implement and operate the products in real production [15]. Another disadvantage is poorly developed professional competencies of the academic staff, as well as the lack of opportunity to continue professional development in accordance with the CDIO standards.

The CDIO Standards (the total number is 12) were designed to standardize the procedure of CDIO implementation into education programmes provided by the institutes worldwide.

However, it is clear that the standard is a kind of archetype, an abstract model, against which other conditions and objects can be compared. There is a wide range of items to be standardized: products, services, activities and operations, documentation, etc. It is noteworthy that a standard is not a stiff requirement but a start point to enhance the activities since the standards themselves are regularly altered, which aims to improve the quality of education provided.

Since a higher education institute is of high social significance in Russia, the educational activities are almost totally standardized. Any deviation from the standard implies a number of options, which require additional efforts to be monitored and controlled. The quality of education provided higher education institutes is controlled by the Ministry of Education and Science and particular monitoring organizations, while the universities which joined the CDIO Initiative bear responsibility for meeting the relevant requirements. For a time, the Agency for Strategic Initiatives and Skoltech held themselves out as professionals in this sphere, however, the Initiative failed to be widely spread among the national universities, and over the past four years, only 10 higher education institutes have joined (Table 2).

Today, there are more than 100 practice-oriented universities worldwide involved in CDIO and implementing CDIO standards. The CDIO collaborators among national higher education institutes are Tomsk Polytechnic university, Skoltech, Astrakhan State University, Moscow Aviation Institute, Moscow Institute of Physics and Technology, Tomsk State University of Control Systems and Radioelectronics, etc. Actually, the CDIO Initiative has not been widely spread throughout the country and its future is not clear, first of all, due to resignation of Edward Crawley, one of the CDIO concept developers and founders,

Table 2. CDIO collaborators among national higher education institutes

№	National Higher Education Institute	Year of joining CDIO Association
1	Tomsk Polytechnic University	2011
2	Astrakhan State University	2012
3	Skolkovo Institute for Science and Technology	2012
4	Moscow Aviation Institute	2012
5	Tomsk State University of Control Systems and Radioelectronics	2013
6	Ural Federal University named after the first President of Russia B.N. Yeltsin	2013
7	Moscow Institute of Physics and Technology	2013
8	Siberian Federal University	2014
9	Kazan Federal University	2014
10	Don State Technical University	2014
11	Cherepovets State University	2014
12	National Research Nuclear University MEPhI	2014
13	The Ammosov North-Eastern Federal University	2015
14	Bauman Moscow State Technical University (BMSTU)	2015
15	Saint Petersburg State University of Aerospace Instrumentation	2015
16	Oryol State University	2016

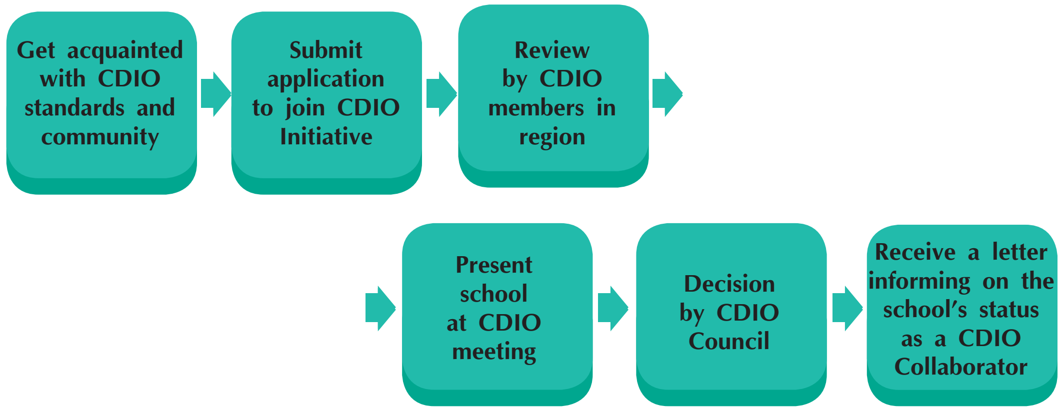
who quitted the post of Skolthech rector. It was professor Crawley who promoted CDIO in Russia and created awareness among the national universities beginning from 2013. It is symptomatic that in 2016 only one national university joined CDIO. Moreover, the advantages of participating in CDIO are not clear since all the standards are open (and even translated) and the university can follow the initiative without joining CDIO.

The steps to join the CDIO Initiatives are given in fig. 3.

As one can see from the figure above, the university should follow the formal procedure, and particular steps (such as presenting school at CDIO meeting) are time and money consuming. There is no formal procedure to control whether the university's educational approaches are appropriate to implement CDIO, and the conference registration fee is 425 €.

The intention of a university to join the CDIO Initiative is supported by neither the Agency for Strategic Initiatives nor Skoltech (which used to hold themselves out as CDIO collaborators in 2013). The last time the information on cdiorussia.ru was updated on July 9, 2013. The national community of CDIO collaborators has not been established. Therefore, the university, which intends to make their educational activities meet CDIO standards, can only join the CDIO Initiative all by themselves.

Fig. 3. Joining the Worldwide CDIO Initiative: series of steps



Conclusion

In conclusion, it is important to emphasize that the prospects of national engineering education are still a topical issue. The CDIO Initiative is one of the most transparent system, which creates a complex picture of adequate engineering education and essential tools to ensure the expected outcomes. In Russia, the rate of interest to the CDIO Initiative is higher than in other countries (except for China), but if the Asian scholars try to transmit their findings into international scientific community, the scholars of the RF publish their papers mostly in Russian.

Today, there are attempts to articulate the original vision of national engineering education, which can be developed as a streamline concept, like CDIO, however, these ideas are difficult to promote and implemented only at particular universities (as well as CDIO). Therefore, one can make a conclusion that none of the concepts on engineering education enhancement can be intensively developed and implemented in the RF without governmental support.

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On the Influence of the Bologna Process on Development of Higher Education in Russia

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Abstract

Among the educational community there is a common opinion of the negative impact of the Bologna process on the national higher education. In the context of FESTFU we can say that the transition to the two-tiered system of education has substantially changed educational and scientific activities of universities. Regulatory framework was developed for ensuring educational and research activities in the terms of the Bologna process. It includes updating teachers' activity, developing their educational and teaching culture, preparing them to effectively use the modern technologies in training and allowing them to bring educational process to a new level.

Key words: educational program, credit-modular system, competence, two-tiered education, teaching material, training.

As is known, in 2011 the Bologna Convention was firmly established in Russia. It had to provide convertibility of Russian diplomas and students'/teachers' academic mobility [2]. Russia's inclusion into European educational zone was suggested to give a strong impetus to integration in national higher education and improve the quality of educational services. This issue is nowadays particularly topical, as the intensive development and engineering innovations continuously change the conditions and quality of professional activity causing specialists to acquire new methods and types of professional skills and competencies as well as regularly improve their qualifications [7].

Strictly speaking, education transition to the Bologna process implies implementation of the four fundamental provisions defining future structure of higher education. It is, first of all, **two-tiered education** (Bachelor, Master) [2]. One can say that the problem was solved by all Russian universities, as there were several Bachelor graduations. However, up to now there are intensive debates among the university communities about the shift from Specialist degree to Bachelor degree training [3].

As I know from my experience as a member of State Examination Board, the difference between a bachelor and a specialist is much more than an additional academic year. Over the last study year as a specialist, the students additionally acquire nearly 50 % of competencies. Meanwhile, I remember the conference (2012), where two professors had a face-to-face argument about Bachelor degree. One of them said that a Bachelor is a half-educated specialist, so employers do not know how to treat it. The other professor argued that at our stores the commodities are produced by those half-trained bachelors from aboard (before import substitution period). So, not only study time matters here, but also smart management of production-oriented educational process.

It should be mentioned that teaching staff is aware of the Bologna process rather superficially, in an ordinary university