IMPLEMENTATION OF CDIO INITIATIVE APPROACH AT A RUSSIAN REGIONAL UNIVERSITY

Aleksandr Lunev (aspu@aspu.ru)

Astrakhan State University

Viktoriia Zaripova (vtempus2@gmail.com)

Astrakhan State University

Irina Petrova (petrova@aspu.ru)

Astrakhan State University

ABSTRACT

To develop the international profile of a Russian university graduate that meets the quality standards and corresponds to modern trends of global high education development, not only future specialist, but also academic staff should change their way of thinking. High school should take the practical initiative, by implementing complex approach, which promotes development of competencies on the basis of, scientific as well as innovative and practical component of university activities. It permits enhancing potential and quality of the knowledge, acquired by the students.

The article considers issues, emerging in a regional Russian university, starting to design educational program, following the principles of Worldwide CDIO Initiative approach. The reasons for Russian Federal State Educational Standard failure to meet international level requirements were identified.

The article dwells on several directions of developing teacher competences, such as carrying out seminars with participation of experts experienced in the sphere of CDIO methodology; the university teachers' studying on master courses organized jointly with the foreign universities of the USA and France; as well as in the framework of "Lean Production and 6 Sigma" course.

KEYWORDS

CDIO, learning outcomes, competencies, educational goals.

INTRODUCTION

One of the main distinguishing features of the new generation of the Russian Federal State Educational Standard (RFSES) is competency approach to educational quality evaluation. New standards were put into action in 2011. The global tendency of learning outcome-based approach to syllabus design was reflected in new RFSES [1].

"Framework" character of the RFSES has become a great improvement. In the 20th century the educational process has been carried out according to the "typical" curricula and syllabus of the disciplines, which were common for the whole country for almost a century. Differences in the curricula of universities did not exceed 10-12%.

Previous generations of educational standards in Russia (the 1st in 1996 and the 2nd in 2000) also contained a strict list of subjects, practices and reporting forms, which a university must adhere to. Level of university independence in curriculum design was 15 – 20% in 1990 – 2000s for the 1st generation of standards, and became about 30% for the 2nd generation of standards.

The 3rd RFSES presupposes further extension of freedom of universities in developing of educational programs; optional part constitutes:

- Up to 50% for bachelor syllabus,
- Up to 70% for master syllabus.

It will allow a regional university to develop new educational programs taking into consideration demands of the local (regional) labor market, scientific and educational traditions of the university, own methodical innovations, as well as to create educational programs, compatible with international requirements.

The article compares several renowned international approaches to syllabi design: Worldwide CDIO Initiative, TUNING Educational Structures in Europe, European EUR-ACE Framework Standards, with the 3rd generation Russian Federal State Educational Standard. The similarities and differences of these approaches are shown and the possibility of implementing international practice of educational degree design based on CDIO concept in a regional university is considered.

The paper cites the results of monitoring of the level of the teaching staff awareness of CDIO system and defines the level of teachers' readiness to implement CDIO in practice. The article also considers the experience of developing teacher competences for professional participation in design of integrated courses programs, tasks for diploma projects according to the planned competencies and expected learning outcomes.

1. COMPARISON OF INTERNATIONAL APPROACHES TO SYLLABUS DESIGN AND THE REQUIREMENTS OF THE RUSSIAN STATE EDUCATIONAL STANDARDS

Independent design of an educational degree is connected with some difficulties for a regional Russian university. It is necessary to study the existing best practices in the world. Results of the comparative analysis of the general requirements of Russian Federal State Educational Standard (RFSES), TUNING Educational Structures in Europe, EUR-ACE Framework Standards (EUR-ACE FS) and The CDIO Syllabus v2.0 are presented in Table 1 and give grounds to assert that all the approaches have common features.

But the following difficult points for Russian universities should be mentioned (Table 1):

- **Absence of common basic terminology**, as well as absence of mechanisms of correlating basic RFSES terminology with conventional European terminology. In Tuning, EUR-ACE FS and The CDIO Syllabus v2.0 the term learning outcomes and competencies (competences)

are used, but in RFSES – the term *competencies* is a full synonym for the term *learning outcomes*. In RFSES, there is no stage of transition of competencies (or knowledge, skills and attitudes set) to learning outcomes on the basis of existing academic, organizational and financial resources as well as strategic objectives of the university.

- **The concept of syllabus objectives is absent**, all the considered approaches are based on defining the learning outcomes according to the institutional mission and vision, program objectives, and institutional and program values. But there is no “objective terminology", requirements for defining and mechanisms for achieving the program objectives in RFSES. This may produce certain difficulties in educational degree design on the basis of RFSES standards in case university adopts EUR-ACE, CDIO or TUNING methodology.

- **There are no unified models, tools and guidelines** for designing educational degree, except for the standard itself, which does not take into consideration (or partially considers) tools of quality and international recognition support, which are adopted in the researched systems.

Basic classification of learning outcomes or graduate’s competencies is the most important issue in designing a curriculum of higher educational programs. Learning outcomes in RFSES, Tuning, EUR-ACE FS and The CDIO Syllabus v2.0 are classified in different ways and they have different formulations. As a result it is difficult to define the connection between RFSES and foreign approaches. We should take into consideration that RFSES as well as TUNING Educational Standards is intended not only for engineering programs, unlike CDIO and EUR-ACE. It leads to a wide range of competency formulation for different profiles, including generic competences.

When writing this article we have researched several papers, which were dedicated to comparative analysis of CDIO and ABET [2, 3, 4], CDIO and EUR-ACE [5, 6], EUR-ACE and Russian National Standards for Master Degree Programs in Computer Science [7]. Our research did not find any papers comparing TUNING methodology with other approaches, except for papers [8-10]. However, a comparison of the list of generic competencies in the Tuning Russia project with the CDIO syllabus is given in paper [8].

This comparison revealed that 25 generic competencies common between Russian and European universities are reflected in the competencies from the CDIO Syllabus v2.0. But this set of generic competencies does not correspond to RFSES in quantity of the competencies and their formulations. In RFSES all the competencies are divided into two groups: general cultural competencies and professional competencies. These two major groups are in its turn are divided into several sub-groups (general professional, constructional design, production and technology activity, management, research, innovative activity). And the quantity of the competencies differs greatly for separate engineering directions in RFSES (range of general cultural competencies is from 12 to 25, and of professional competencies – from 15 to 55).

Consequently the issue is what system of basic classification of learning outcomes to choose as a starting point in curriculum design, if a university wants to request national Russian accreditation or European accreditation or ABETS accreditation.

Table 1. Comparative analysis of best systems of organization and quality control of higher educational programs for engineering specialties.

	RFSES	**EUR-ACE**	**CDIO**	**TUNING**
Target degrees	All	Engineering	Engineering	All
		Analysis-Design-Investigation	*Conceive-Design – Implement Operate*	*Reference, convergence and common understanding.*
Tools	3rd Generation of Federal State Educational Standards	Program outcomes for 1st and 2nd cycle engineering degrees. Guidelines and procedure for program assessment and accreditation.	CDIO syllabus, CDIO standards, CDIO self-evaluation	National generic and subject-specific competences; Tuning model for designing, implementing and delivering curricula; approaches to learning, teaching, and assessment
Basic terminology	Competencies (general, instrumental), credits (1 credit = 36 hours),	Program outcomes, learning outcomes, educational programs	Knowledge, Skills and attitudes; Learning Outcomes	Workload (ECTS), levels, learning outcomes, competences, profiles, units
Quality assurance tools	ACCREDITATION		SELF-EVALUATION	
	Russian state accreditation methodology, Central Database of State Accreditation, State Educational Standards, *The Best Educational Programs in Russia [11]*	European system of accreditation of engineering educational programs (ENAEE, 2009), Guidelines and procedure for program assessment and accreditation	CDIO syllabus, CDIO standards, CDIO self-evaluation (feedback to stakeholders)	National and international expert bodies, dynamic quality development circle for program level [12], transparent feed-back and feed-forward instruments
International recognition	No qualification framework, internal, lack of uniformity in definition of competencies, even in one subject area, very strict mechanism of student workload calculation	European Qualification Frameworks, ECTS, detail list of program's outcomes for 1st and 2nd cycles of engineering degrees	DOCET project, very good alignment with other outcome-based taxonomies developed by national accreditation and evaluation bodies [2,13]	Degree Profiles on base of EQF, CoRe projects (transparency and academic recognition of the degree profile within Europe) [14]

2. MONITORING OF THE LEVEL OF THE TEACHING STAFF AWARENESS OF CDIO SYSTEM

Three components constitute the core of the CDIO approach to design, development and quality evaluation of a degree:

- Employment CDIO Syllabus, to define the program objectives, i.e. what program aspires to achieve.

- Employment of 12 Standards as guidelines to design and manage the program, i.e. how the objectives of the program are achieved.

- Employment of CDIO Self-evaluation to measure the program advance in fulfilling CDIO standards, i.e. the progress of the program accomplishment.

Standards reveal the philosophy of the program, guide the program development, help to plan and develop infrastructure for successful functioning of the program, new teaching methods implementation. A special attention is given to improvement of competence of the teachers: integrated practical classes are carried out, methods of active learning are implemented in the teaching process, as well as in the student progress evaluation.

After ASU joined the Worldwide CDIO Initiative in March 2012, the first monitoring of the level of the teaching staff awareness of CDIO system was carried out. The monitoring was aimed at defining the level of awareness and readiness to implement the CDIO approach of the teaching staff of the university and at choosing the divisions, which are most motivated and ready to implement CDIO Initiative.

200 teachers and staff members of 16 faculties of ASU took part in the research (Figures 1 and 2). Faculties were divided into two groups:

- Natural Science and Engineering Faculties: Physics and Technology Faculty, Faculty of Mathematics and Information Technology; Architecture and Design Faculty; Agriculture Faculty, Geology and Geography Faculty, Faculty of Biology, Faculty of Chemistry.

- Humanity Faculties: Faculty of History, Faculty of Social Sciences, Faculty of Psychology, Faculty of Pedagogics, Social Work and Physical Education, Faculty of Linguistics and Journalism; Faculty of Foreign Languages; Faculty of World Economy and Management; Faculty of Business and Economy; Faculty of Jurisprudence.

Comparative results of awareness and readiness to implement CDIO standards on the part of the Humanity Faculties is especially interesting as they are motivated to modify the CDIO principles creatively and to reformulate them for specialists of non-technical degrees.

Comparison of diagrams of Figures 1 and 2 reveals that humanity faculties staff show high awareness level in the sphere of CDIO Standards as well as the engineering specialty staff. The special attention is given to the following standards:

Standard 8. Active learning

Standard 9. Enhancement of Faculty CDIO Skills

Standard 7. Integrated learning experiences

Standard 10. Enhancement of Faculty Teaching Skills. Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods and in assessing student learning

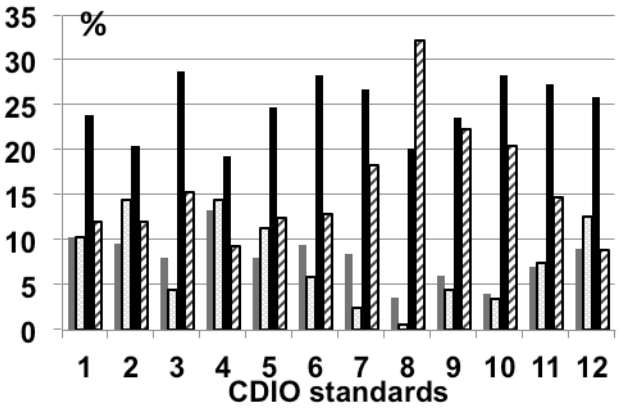

Fig. 1 Distribution in Humanities courses.

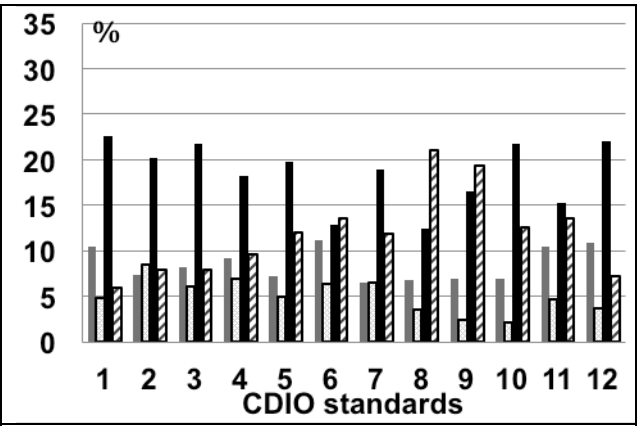

Fig. 2 Distribution of positions in engineering courses.

	Don't know		Know and ready to apply while teaching in some conditions
	Know but is not ready to apply while teaching		Know and absolutely ready to apply while teaching

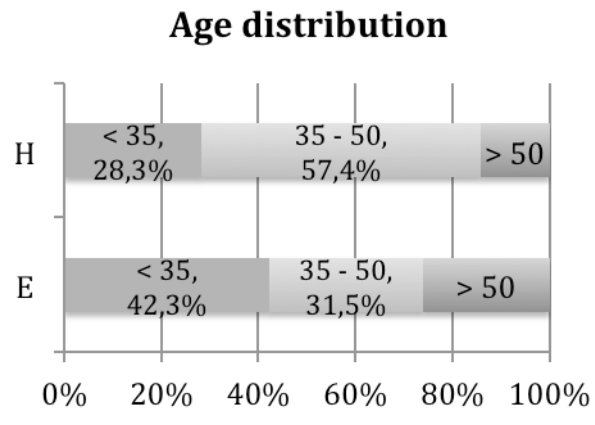

Fig. 3 Age distributions. H – Humanity faculties, E – Engineering and Natural Science faculties

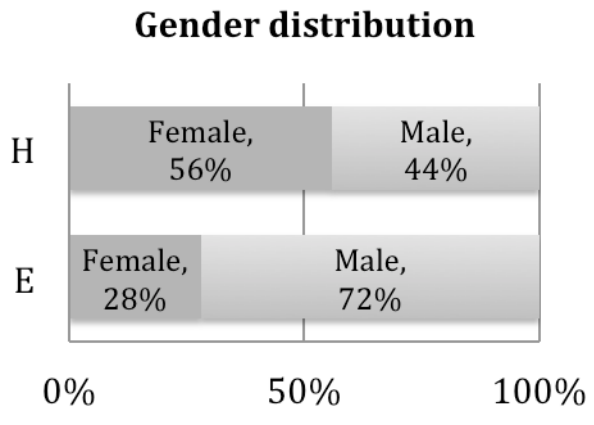

Fig.4 Gender distribution. H – Humanity faculties, E – Engineering and Natural Science faculties

We can conclude that teaching staff of Humanities faculties is interested in implementation of CDIO approach and in application of active learning methods, integrated educational tasks in elaboration of courses and programs.The faculties implementing courses of engineering and natural sciences are also ready to apply CDIO standards, if some conditions are met. Primarily this is the necessity of resources provision (special laboratories, training rooms, where students

could implement their projects during their free time, organization of externships at enterprises for students and traineeships for the teaching staff).

Analysis of statistic data leads to an assumption about the causes of higher propensity of teachers in the humanities that allows them to introduce the principles of CDIO in their work:

- A higher percentage of teachers of the average age in humanities faculties. On the one hand they have enough experience to estimate the benefits and the possibility to introduce the system on their faculties, and on the other hand they are less critical than the elder generation. At the same time the opinion of senior colleagues and professors in engineering departments is more important and respectful for their colleagues, especially young teachers, who often begin as graduate students in the departments. Thus, we can say that the engineering faculties initially are more critical with respect to any innovation. A greater percentage of female teachers, heads of department and deans of humanities also speaks in favor of this assumption.

- Analysis of the suggestions for the special teaching conditions (e.g. more modern laboratory equipment, master classes of practioners from partner companies, more hours of workload and the necessity to involve assistants to supervise the students, the purchase of expensive software or training aids, provision of a large number of open-access work places and open centers of project-oriented education) allows us to make a conclusion that the organization of the teaching process in the technical specialties in accordance with the principles of CDIO generally requires more special-purpose resources, and that is well known by the teachers. On the other hand the humanitarian projects can be implemented in ordinary university facilities.

It is also necessary to point out that in spite of the fact that in Russian Universities there is no common practice of combining teaching experience with the SME-work background, professors of humanities have wide experience of working with the real projects. Since 2008, all the University departments participated in the cooperation project with the region authorities. The project implied the idea of creating the interdisciplinary teachers teams and assisting the heads of municipalities in the development and launching the social projects. In this case, teachers of engineering were involved only when necessary, while teachers of humanities made up the core of the project.

It is worth mentioning that a number of faculties since 2010 has been members of Tuning – Russia project on tuning educational programs of bachelor and master degrees [15], that is being implemented within TEMPUS project and includes 12 Russian and 4 European establishments of higher education (Spain, the Netherlands, Ireland and Italy) and Association of Classical Universities of Russia that represents 44 universities of Russia. The participating universities promote the adaptation of Tuning methodology in RU universities in specific areas: Information and Communication Technologies, Economics and Management, Psychology and Pedagogic Education, Engineering Ecology, Jurisprudence, Tourism, and Ecology. This collaboration allows ASU to analyze various approaches to the principles of the Bologna Process and the TUNING methodology.

Within the frame of TUNING-RUSSIA project Russian universities-members of the consortium questioned 358 employers and 187 members of universities teaching staff. The questionnaires contained lists of generic competences (30 competences formulated by the experts from Russian and foreign universities on the basis of European competences of Tuning project and taking into account Russian specific characteristics) [8]. The interviewees were asked to

determine the relevance of each of the 30 competences for the professional work in the specified sphere. The review was carried out in accordance to the Tuning Dynamic Quality Development Cycle [12] requirements and 4-point rating scale was used, 1 (min) to 4 (max) (1 = none; 2 = weak; 3 = considerable; 4 = strong). The comparative analysis of process and methodology in TUNING-Europe and TUNING-USA pilot project (three states (Minnesota, Indiana and Utah) and six disciplines (biology, chemistry, education, history, physics and graphic design), see www.TuningUSA.org) allowed to illuminate the common tendency. For example in the USA students and employers do not consider certain competences that educators believe are important very relevant – this is the case in Europe and Latin America. All three reviews used the EU list of generic competences. In some cases this was simply because there were competences, which have little to do with the concerns of the historian (workplace safety), in others – teamwork, project management, a second language – showed differences among the various respondents. [16]

The analysis of competences by their relevance for two focus-groups (employers, teaching staff) in Russia also allows to find out the divergence of views of the groups' members and to direct the efforts of the university to a more complete understanding of the employers' opinion while elaborating the educational program (Fig.2).

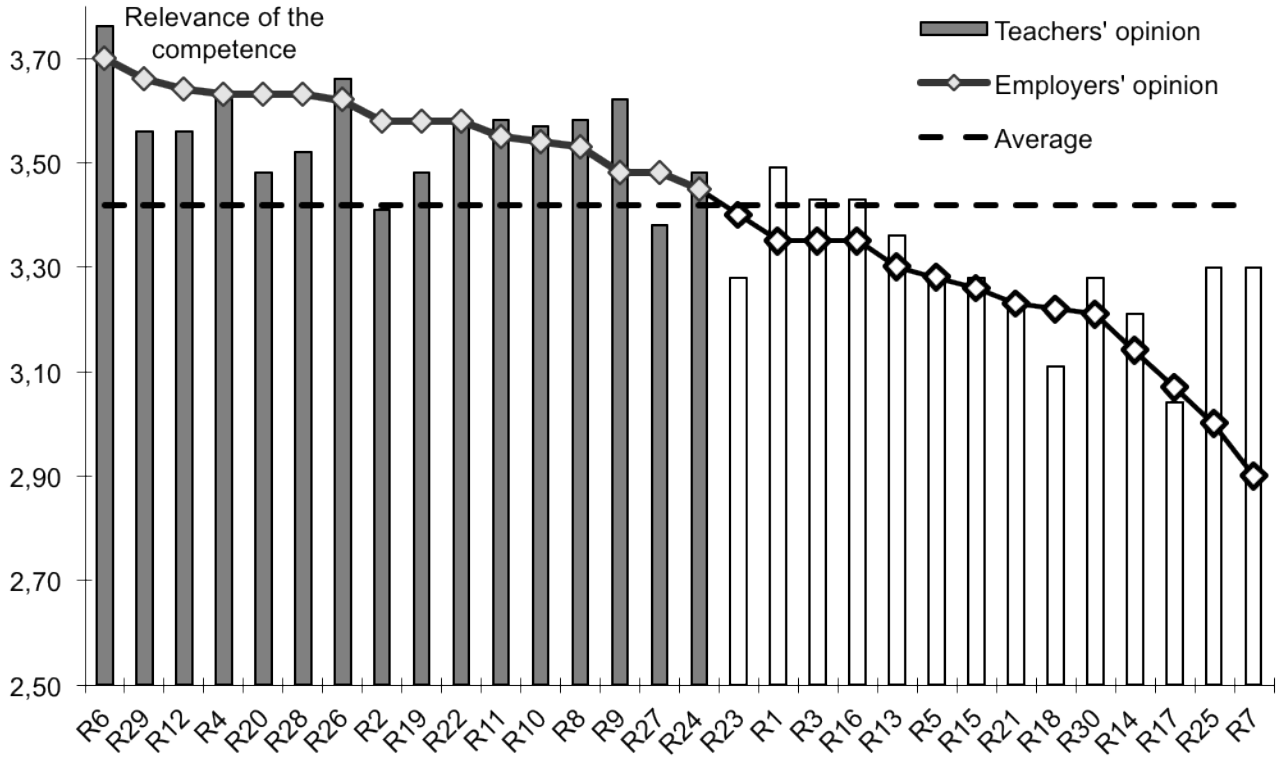

Figure 5 Summary diagram of the estimation of generic competences by teaching staff of Russian universities (green) and employers (red line)

The average rating on the 4-point scale across competencies for employers respondent group is 3.41 (the top dotted line). The competencies that received ratings below the average (in accordance to the employers point of view) were considered less important and, therefore, were not included in the subsequent analysis (right part of the figure with the empty bars).

The analysis of the diagram shows that the utmost coincidence of views of employers and teaching staff (divergence of views on the relevance is 0.01) relates to the following competences:

R22	E10	Ability to find, process and analyze information from various resources
R4	E14	Ability to define, formulate and solve problems
R5	E23	Ability to design and manage projects
R21	E11	Ability to critical thinking and self-criticism

Below one can find a list of competences, which are important from the employers' viewpoint and insignificant from the teaching staff's viewpoint (the estimation of the opinion divergence is stated in the last column of the table). In Table 2 the competences are ranged with the decrease of the degree of relevance from the viewpoint of employers.

Thus it is necessary to make the teaching staff change their view to create in the institute an "innovation environment" aiming at generating and implementing ideas, commercialization of the results; training leaders able to create teams and implement projects, to run small innovative enterprises

Table 2. List of competences with maximum divergence in the relevance estimation.

Competence number		Competence title	Estimation divergence rate
Russia	EU		
R29		Result orientation	0,10
R12	E15	Ability to make reasoned decisions	0,08
R20	E27	Ability to evaluate and maintain the quality of work produced	0,15
R28		Ability to focus on quality	0,11
R2	E16	Ability to work in a team	0,17
R19	E3	Ability to plan and manage time	0,10
R27		Ability of conflict settlement and negotiating	0,10
R23	E24	Responsibility to security matters	0,12
R18	E19	Ability to discuss the professional issues with nonexperts	0,11
R17	E29	Loyalty to the idea of environmental safety	0,03

3. IMPLEMENTATION OF CDIO STANDARDS ON ENHANCEMENT THE FACULTY SKILLS

Enhancement of the teaching staff skills (Standards 9 and 10) is implemented by means of workshops with the experts from foreign universities and joint master degree programs with US institutes. Besides ASU has elaborated course "Lean production+ 6 sigma" designed for a more comprehensive knowledge of trainees in the sphere of modern production management and forming the skills and competences for professional participation in elaboration of development tactics and strategy for small innovative companies, increasing their competitiveness.

To study the principles of restructuring of syllabuses and organization of educational process in compliance with CDIO approach in 2012 the university held 2 events inviting leading foreign scientists:

International workshop “New Approach to Engineering Education – CDIO Project” (May 2012) with David C. Wissler, PhD, member of National Academy of Engineering (NAE) (USA), Vice-president of American Society of mechanical Engineers.

International conference “New Approach to Project-Based Education – Worldwide CDIO Initiative” (November 2012) with invited Professor Aldert Kamp - Director of Education Aerospace Engineering TU Delft (the Netherlands) and Professor Juha Kontio - Director of Education; Faculty of Telecommunication and e-Business, Turku University of Applied Sciences (Finland).

In the course of the workshops and conference teachers and students (last year of BA and MA students) studied both the fundamental CDIO principles and more individual issues like methods of active involvement of the students in the training process and experience of other instates in organization of training process and project based education. The progress self-evaluation report (between May and November) was used in preparation of the paper (Fig. 1- 4). The next evaluation is waiting to be at the end of the fall semester.

Among the problems we should mention the problem of communication with foreign partners for most of the students and teachers do not master foreign languages well enough. The university is implementing 3 joint master degree programs together with Clark university (Worcester, MA, USA). In the course of these programs ASU teachers have not only gained considerable experience and mastered the best methods of their foreign colleagues but have also improved their English language skills. As a result ASU was provided with new interactive pedagogical methods: case method, teamwork, group projects. Students, teachers and employers have highly appreciated introduction of these methods into the training process.

Course “Lean production+ 6 sigma”, elaborated by ASU, is designed for a more comprehensive knowledge of trainees in the sphere of modern industrial management and forming the skills and competences for professional participation in elaboration of development tactics and strategy for small companies, increasing their competitiveness [8]. Methods of case study, analytical discussions, debates, expert decision making and business games are used as the basic forms and methods of training, that is in full compliance with CDIO Standard 8.

During the course participants will gain Lean management philosophy and several of the tools for streamlining production and services from end to end with a focus on the elimination of waste, and skills in Six Sigma, such as data investigation and creative problem solving. Six Sigma focuses on a lowering of occurrences of defects in the products or services of the organization in order to improve overall quality. The main attention is paid to the problem-solving framework for improving processes, DMAIC or Define, Measure, Analyze, Improve, Control, which interact with CDIO (Conceive – Design – Implement – Operate) in organic and synergetic way.

The course includes training of the following competencies:

- NoR2 Ability to work in a team
- NoR5 Ability to design and manage projects
- NoR11 Ability to work autonomously

- NoR12 Ability to make reasoned decisions
- NoR19 Ability to plan and manage time
- NoR20 Ability to evaluate and maintain the quality of work produced
- NoR28 Ability to focus on quality

CONCLUSION

Regional establishment of higher education in Russia while independent designing of an educational program faces some difficulties, related to some reasons:

1. There is no unified terminology approved at the international level and adjusted to the terms of Russian standards (RFSES). It is necessary to elaborate a glossary of terms for designing educational programs.

2. RFSES has no requirements for defining educational objectives and mechanisms for their achievements. It is necessary to adjust international experience by formulation the objectives of an educational program to use it in RFSES.

3. All the programs of regional establishments of higher education in Russia must obtain state accreditation. Thus it is required to develop basic classification of the results of the education and competences of the graduate in a specified direction that will ensure compliance of the program to national and international requirements.

Interview of the teachers showed that CDIO ideology and standards can be applied to training of specialists of any profile. This project-based technology that is focused on the student and integrated with the problems and experience of real production. The university is planning to spread this initiative on natural sciences and then to the humanities.

Comparison of the views of teachers and employers revealed the necessity to make the teaching staff change their view to create in the institute an “innovation environment” aiming at generating and implementing ideas, commercialization of the results; training leaders able to create teams and implement projects, to run small innovative enterprises.

Enhancement of the teaching staff competence is implemented by means of workshops with the experts from foreign universities and joint master degree programs with US institutes. Besides ASU has elaborated course “Lean production+ 6 sigma” designed for a more comprehensive knowledge of trainees in the sphere of modern production management and forming the skills and competences for professional participation in elaboration of development tactics and strategy for small innovative companies, increasing their competitiveness.

GLOSSARY

- CoRe project (http://www.core-project.eu/) stands for Competences in Education and Recognition. CoRe2 was a two-year project funded under the Lifelong Learning program and conducted by a consortium of ENIC/NARICs, Tuning and the Dutch Flemish Accreditation Organization (NVAO).
- DOCET - DOCET project relates to the themes of Recognition of credits, degrees and qualifications between Europe and third countries, Mutual recognition of qualifications with third countries and Promotion of the use of the European qualifications framework and ECTS. (http://www.eqfcdio.org/home)

- ECTS - The European Credit Transfer and Accumulation System is a student-centered system based on the student workload required to achieve the objectives of a program, objectives preferably specified in terms of learning outcomes and competences to be acquired.
- ENAEE - European Network for Accreditation of Engineering Education) (http://www.enaee.eu/) the European network which authorizes accreditation and quality assurance agencies to award the EUR-ACE® label to accredited engineering degree programs.
- EQF - European Qualifications Framework (EQF) acts as a translation device to make national qualifications more readable across Europe, promoting workers' and learners' mobility between countries and facilitating their lifelong learning.

REFERENCES

[1] N.N. Fomin, N.P. Reznikova The 3rd generation of Russian State Educational Standards: competence approach and influence of employers, SEFI 36th Annual Conference July 2 - July 5 2008, Aalborg, Denmark, Retrieved January 08, 2013, from http://www.sefi.be/wp-content/abstracts/1006.pdf

[2] E.F. Crawley, J. Malmgvist, W.A. Lucas, D.R, Brodeur (2011) The CDIO Syllabus v 2.0. An Updated Statement of Goals for Engineering Education Proc. of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June 20-23, 2011.

[3] P.Armstrong and R.Niewoehner The CDIO approach to the development of Student skills and attributes Proceedings of the 4th International CDIO Conference, Hogeschool Gent, Gent, Belgium, June 16-19, 2008

[4] Bankel, J., Berggren, K.-F., Blom, K., Crawley, E. F., Wiklund, I., & Östlund, S. (2003). The CDIO syllabus - A comparative study of expected student proficiency. European Journal of Engineering Education, 28(3), 297–315. doi:10.1080/0304379031000098274

[5] A.I.Chuchalin RAEE accreditation criteria and CDIO syllabus: Comparative analysis Proceedings of the 8th International CDIO Conference, Queensland University of Technology, Brisbane, July 1 - 4, 2012

[6] J. Malmqvist A Comparison of the CDIO and EUR-ACE Quality Assurance Systems International Journal of Quality Assurance in Engineering and Technology Education, 2(2), 9-22, April-June 2012 9 (DOI: 10.4018/ijqaete.2012040102)

[7] A.I. Surygin Comparison of EUR-ACE and Russian National Standards. Requirements for Master Degree Programmes in Computer Science, SEFI 40-th Annual Conferece, 23-26 September 2012, Thessaloniki, Greece, Retrieved January 07, 2013, from http://www.sefi.be/conference-2012/Papers/Abstracts/ECD-EAST%203.pdf

[8] A.Lunev, I.Petrova, V.Zaripova Competence-based model of learning for engineers and the future of university education Proceedings of the 8th International CDIO Conference, Queensland University of Technology, Brisbane, July 1 - 4, 2012, Retrieved January 07, 2013, from http://www.cdio.org/files/document/file/competencebasedengineersfutureuniversityeducation.pdf

[9] R.Gluga, J.Kay, and T.Lever Foundations for modelling university curricula in terms of multiple learning goal sets, Retrieved January 08, 2013, from http://sydney.edu.au/engineering/it/~judy/Homec/Pubs/2012_IEEE_TLT_CUSP.pdf

[10] M.Palma, I. de los Ríos, E. Miñán Generic competences in engineering field: a comparative study between Latin America and European Union Procedia Social and Behavioral Sciences 15 (2011) 576–585

[11] Galina Motova & Ritta Pykkö Russian Higher Education and European Standards of Quality Assurance, European Journal of Education, Vol. 47, No. 1, 2012

[12] Quality enhancement at programme level: The Tuning approach. http://www.unideusto.org/tuningeu/quality-enhancement.html

[13] António Costa, Ângelo Martins, Fátima Rodrigues, João Rocha CDIO@ISEP: "A stairway to heaven" (a CDIO contribution to EUR-ACE certification), Proceedings of the 8th International CDIO Conference, Queensland University of Technology, Brisbane, July 1 - 4, 2012
[14] CoRe Projects Competences in Education and Recognition http://www.core-project.eu/
[15] Tuning Russia\List of Generic Competences, Retrieved January 08, 2013, from http://www.tuningrussia.org/index.php?option=com_content&view=article&id=69&Itemid=74&lang=en
[16] Co-operation in Higher Education between the United States of America and the European Union to produce a robust methodology to evaluate the application of the Tuning approach. European Commission Education & training. 2010. http://ec.europa.eu/education/eu-usa/doc/tuningreport_en.pdf.
[17] Tuning Educational Structures in Europe // http://www.unideusto.org/tuningeu/
[18] A Tuning Guide to Formulating Degree Programme Profiles, Editors:J.Lokhoff and B.Wegewijs (Nuffi c), K.Durkin (UK NARIC), R.Wagenaar, J.Gonzalez, A.K.Isaacs, L.F. Dona dalle Rose and M.Gobbi (TUNING) Bilbao, Groningen and The Hague, 2010, Retrieved January 07, 2013 (http://www.unideusto.org/tuningeu/images/stories/documents/)
[19] Gonzalez, Julia and Robert Wagenaar, eds., Tuning Educational Structures in Europe. Universities' contribution to the Bologna Process. An introduction. Bilbao and Groningen, 2nd. ed. 2008.
[20] ENAEE. (2008). EUR-ACE framework standards for the accreditation of engineering programmes. Retrieved January 07, 2013 from http://www.enaee.eu/eur-ace-system/eur-ace-framework-standards
[21] ENQA. (2009). Standards and guidelines for quality assurance in the European higher education area (3rd ed.). Retrieved January 07, 2013 from http://www.enqa.eu/files/ESG_3edition%20(2).pdf.
[22] European Communities. (2008). The European qualification framework for lifelong learning (EQF). Luxemburg. Office for Official Publications of the European Communities. Retrieved January 07, 2013, from http://ec.europa.eu/education/pub/pdf/general/eqf/broch_en.pdf
[23] Terminology of European education and training policy-a selection of 100 key terms.. CEDEFOP, Luxembourg: Office for Official Publications of the European Communities, 2008. Retrieved January 07, 2013, from http://www.cedefop.europa.eu/EN/publications/13125.aspx
[24] Recommendation of the European Parliament and of the council (of 18 June 2009) On the establishment of a European Credit System for Vocational Education and Training (ECVET) Official Journal of the European Union , 8.7.2009, pp 155/11
[25] DOCET EQF – CDIO : a reference model for engineering education A guide for developing comparable learning outcomes to promote international mobility (final report), Retrieved January 08, 2013, from http://www.eqfcdio.org/project-outcomes/cat_view/15-project-documents

BIOGRAPHICAL INFORMATION

Alexander Lunev, Doctor of Economic Sciences, Professor, Rector of Astrakhan State University. His scientific objectives - Lean Production Philosophy and its implementation into the educational process management at the University.

Irina Petrova, Doctor of Technical Sciences, Professor, Vice-Rector of ASU. Her scientific objectives – creation of informational systems to support engineering creativity and formation of the new CAI systems (Computer Aided Innovation).

Viktoria Zaripova, Candidate of Technical Sciences, Associate professor at the «Information Systems» Department (ASU). Her scientific objectives – the process of international integration of education, the study of educational systems in different countries and creation of informational systems to support engineering creativity.

Corresponding author

Prof. Irina Petrova
Astrakhan State University
20A Tatischeva street
Astrakhan, Russia 414056
7-8512-610803
petrova@aspu.ru