UPDATING OF CDIO STANDARDS IN AGRICULTURAL ENGINEERING EDUCATION

Egor Vladimirovich Kulaev, Dmitry Ivanovich Gritcay, Mikhail Vladimirovich Danilov, Svyatoslav Sergeevich Serikov and Valentina Anatolyevna Ivashova

CES, Stavropol State Agrarian University, Stavropol, Russia

ABSTRACT

The article describes the stages of engineering education programs updating for training specialists in agricultural production based on the views of stakeholders: employers, lectures and students. Employers of the North Caucasus region, university professors, students of educational programs “Agro Engineering”, the profile “Technical Systems in Agribusiness” expressed their opinion on the ideal learning outcomes. Priorities placed in the attributes of an ideal model of an agro engineer differ in categories of stakeholders. A comparative analysis of the stakeholders' expectations and the characteristics of implemented educational programs of higher education for the training of agro engineers has shown the need to consolidate the disciplinary blocks into educational modules, strengthen project training and develop entrepreneurial skills and operational thinking.

Key words: attributes of professional activity, agro engineer, educational program, educational program stakeholders, survey, CDIO Standards.


1. PROBLEM STATEMENT

The development of modern engineering systems and technologies, their material and technical support require unification and standardization in the training of engineering personnel, ensuring their readiness for the actual production process. A large-scale international CDIO project on modernization of basic engineering education with the participation of scientists, lectures and industry representatives is gaining its relevance in the agricultural sector. It is important to bring the content and effectiveness of engineering educational programs in line with the level of development of modern technologies and employers’ expectations.
The process of the CDIO Standards updating was carried out within the framework of the educational program of higher education 35.03.06 – Agro Engineering, training program (profile) “Technical Systems in Agribusiness” and was implemented by Stavropol State Agrarian University.

The improvement of the educational program “Agro engineering” is relevant, since agricultural producers of the Stavropol Territory and southern Russia are interested in this (LLC Agricultural Enterprise “Chapaevskoe”, agricultural production co-operative collective farm – stud farm “Kazminsky”, agricultural production co-operative stud farm “Rossiya”, LLC “AIC Agrostandart”, LLC combine harvester manufacturer “Rostselmash”, CJSC “Rossiskaya Instrumentalnaya Kompaniya”, LLC “STC – SERVIS”, CJSC KPK “Stavropolstroyopttopg”, agricultural production co-operative collective farm “Rodina” etc.).

Reforming the educational program on the basis of CDIO standards will increase interest in a priority for the university and the region, thereby increasing the number of students enrolled on a commercial basis. There are facilities and resources that fully ensure the implementation of the program using a practice-oriented approach and teamwork. The technical specialization of this training area allows students to be engaged in the design and manufacture of innovative equipment for the agribusiness and food industry [1, 2].

The unique character of the educational program lies in the technologies of its design and support, developed in accordance with international standards of engineering education CDIO Standards:

1. Planning of learning outcomes is based on the results of a survey of 132 stakeholders.
2. The distribution of learning outcomes is implemented by the modules of the educational program in accordance with international learning outcomes presented in the CDIO Syllabus.
3. The achievement of the results of the development of the educational program is carried out through the development of a group of interrelated competencies (general cultural, general professional, professional, professional-applied, additional) that compose the enlarged learning outcomes, which are formed in the framework of the modules (constituting their disciplines) and enable the graduate to realize a certain type of professional activity and the corresponding specific labor functions and professional tasks. The concept of the educational program is based on the CDIO approach to the expected learning outcomes and is focused on the following tasks:
   – focus on a modular education system;
   – the choice of individual educational trajectories by students;
   – practice-oriented training that allows to combine fundamental knowledge with practical skills according to the direction of training;
   – formation of university graduates’ readiness for active professional engineering and design activities.

Scientists Kohn Rådberg, K., Lundqvist, U., Malmqvist, J., Hagvall Svensson, O. in the article “From CDIO to challenge-based learning experiences – expanding student learning as well as societal impact?” presented their vision of the development of the CDIO concept. They suggest considering challenge-based learning (CBL) as an evolution of the CDIO concept (Conceive, Design, Implement, Operate), expanding as well as deepening the learning experience. In their opinion, there is a growing need to introduce this multidisciplinary approach, which encourages students to actively work with peers, professors and stakeholders in society to identify complex problems, formulate relevant issues and take measures for sustainable development. Research results show that students have developed profound skills in developing projects for the sustainable development of society in collaboration with various
stakeholders. Even though only part of the projects reaches the implementation stage, there is a potential for social impact and effect both during and after the learning experience [3].

On the relevance of the introduction of the CDIO concept, the arguments were expressed by the researchers Yanagibashi, H., Naoe, N. in the article “Practical example of technical college’s engineering education through external contest”. CDIO based engineering education can be more effectively implemented through practical skills in external competitions such as Robocon. This time, a competition of ideas for the development of micro hydropower engineering was experimentally selected for the electrical engineering and electronics. The results showed that there were a lot of CDIO elements in the competition. Students experienced various types of engineering activities that took into account the real needs of the region. Therefore, the authors concluded that participation in external competitions is very effective for engineering education, focused on the CDIO initiative. It is also necessary for lectures to work with companies, municipalities and citizens to prepare a variety of competitions that are useful for the region and are areas of increased professional competence for students [4].

The relevance of operational thinking, as one of the main results of an engineering training, is discussed in the research of Ercan, M. F., Caplin, J., the results of which are published in the article “Enabling systems thinking for engineering students”. Scientific and technological progress in various fields of science and technology led to the possibilities of wide users’ access to complex engineering systems in everyday life. Accordingly, to participate in the maintenance of these systems, modern engineers require a wide range of skills. To deal with complex engineering systems, an engineer must be well versed in various technical areas, such as computing, electrical engineering and mechanical engineering, as well as have the competence of operational thinking. These requirements of a modern production environment can be met by introducing a multidisciplinary project-based approach to learning – CDIO. In their experience in training of modern engineers, scientists with the help of modular design training combined individual practical skills of students in systems engineering design [5].

Thus, it can be said that researchers assign an important place to the implementation of CDIO Standards in the modern engineering personnel training [6–9].

**Goal of the study:** To determine the expectations of different categories of stakeholders about the important attributes of the future professional activity of an agricultural production engineer in accordance with the CDIO. To consider the impact of these expectations on the design of an engineering education program.

### 3. MATERIALS AND METHODS

The research methods are the analysis and synthesis of stakeholders’ ideas about possible models of an agricultural production engineer in accordance with the CDIO. The learning outcomes of the engineer of the agricultural production sector are based on: FSES HE, CDIO Syllabus and stakeholder surveys.

It is proposed to introduce the following categories of stakeholders:

1. Employers with whom, at the time of the development of the curriculum, the department which is responsible for the admission interacts.
2. Academic-teaching staff who taught in this area.
3. Students of Bachelor and Master Degree programs who study in this and other directions of educational program.

In the process of the survey, the stakeholders were asked to: complete a tabular form for assessing the importance of learning outcomes and make their own suggestions regarding the formulation of results.
From among the stakeholders, 132 people took part in the survey.
During the survey, the stakeholders described the attributes of the graduate and assessed the importance of competencies.

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

4. PRESENTATION OF THE MAIN MATERIALS OF THE STUDY
The educational program of the Bachelor Degree is aimed at the implementation of the Federal State Educational Standards of Higher Education in the direction of training. 35.03.06 – Agro Engineering and on this basis, the development of students’ social and personal qualities, as well as the formation of general cultural, general professional and professional competencies in accordance with the requirements of the Federal State Educational Standards of Higher Education in this area of training, contributing to its social mobility and sustainability in the labor market; formation of bachelors readiness for active professional and project activities, personal qualities and cultural and ethical values. The educational and project activities of students are aimed at developing technical means for the technological modernization of agricultural production; effective use of agricultural machinery and equipment in the production, storage and processing of crop and livestock products.

The mission of the educational program in the direction of training 35.03.06 – Agro Engineering is the active promotion of the growth of the effectiveness of educational, scientific and production activities of the agro-economic cluster of the region by training highly educated personnel in a multi-level modular system of continuing professional education, taking into account the dynamic characteristics of the core and qualification structure of the agricultural labor market.

The educational program is developed on the basis of the FSEP HE, taking into account the CDIO concept and the results of interviewing and questioning of stakeholders (employers, students, lectures), who described their ideas about the expectations of the qualities of a graduate.

Of all the learning outcomes presented by the stakeholders, it is possible to form a basic requirement for the results of the learning program mastering: formation of general cultural, general professional and professional competencies of students to expand the boundaries of knowledge and training, increase of the graduates competitiveness through adaptation to modern production equipment and technological processes, development and implementation of high technology projects.

The area of professional activity of the graduate, the types and tasks of professional activity in the direction of training 35.03.06 – Agro Engineering are agreed with the representatives of employers - social partners and include:
– effective use and maintenance of agricultural machinery and equipment, means of electrification and automation of technological processes in the production, storage and processing of crop and livestock products;
– development of technical means for technological modernization of agricultural production.

The objects of professional activity of graduates who have mastered Bachelor Degree programs are: machine technologies and systems of machines for the production, storage and transportation of crop and livestock products, technologies and means of production of agricultural machinery; technologies of maintenance, diagnosis and repair of machinery and equipment; methods and means of machines testing; machines, installations, devices and
equipment for the storage and primary processing of crop and livestock products, as well as technologies and technical means of processing manufactories and enterprises.

Types of professional activity for which graduates who have mastered the Bachelor Degree program are preparing: project; production and technology; organizational and managerial.

The results of the survey of stakeholders are presented in the form of average points on a ten-point scale in segmentation by categories of stakeholders: employers, lectures, students (Table 1).

Table 1 The results of the stakeholders’ survey

<table>
<thead>
<tr>
<th>Qualities of the future engineer</th>
<th>Students, average points</th>
<th>Lectures, average points</th>
<th>Employers, average points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DISCIPLINARY KNOWLEDGE AND BASIS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic knowledge of mathematics, physics</td>
<td>8.1</td>
<td>8.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Key knowledge of engineering fundamentals</td>
<td>8.8</td>
<td>8.9</td>
<td>8.7</td>
</tr>
<tr>
<td>In-depth knowledge of the basics of engineering, methods and tools</td>
<td>9.2</td>
<td>9.0</td>
<td>9.2</td>
</tr>
<tr>
<td>2. PROFESSIONAL COMPETENCIES AND PERSONAL QUALITIES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1. Analytical rationale and problem solving</td>
<td>8.3</td>
<td>7.9</td>
<td>8.8</td>
</tr>
<tr>
<td>2.2. Ability to conduct experiments, research</td>
<td>7.9</td>
<td>8.7</td>
<td>8.6</td>
</tr>
<tr>
<td>2.3. Operational thinking</td>
<td>8.9</td>
<td>8.9</td>
<td>9.3</td>
</tr>
<tr>
<td>2.4. Ethics, justice and other responsibilities</td>
<td>7.9</td>
<td>8.4</td>
<td>8.4</td>
</tr>
<tr>
<td>3. INTERPERSONAL SKILLS: WORKING IN A TEAM AND COMMUNICATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1. Ability to carry out effective interaction with people around</td>
<td>9.0</td>
<td>8.3</td>
<td>8.8</td>
</tr>
<tr>
<td>3.2. Ability to manage a team</td>
<td>9.0</td>
<td>8.9</td>
<td>9.0</td>
</tr>
<tr>
<td>3.3. Ability to carry out effective communication in foreign languages</td>
<td>7.4</td>
<td>6.9</td>
<td>8.3</td>
</tr>
<tr>
<td>4. PLANNING, DESIGN, PRODUCTION AND APPLICATION OF PRODUCTS (SYSTEMS) IN THE CONTEXT OF THE ENTERPRISE, SOCIETY AND ENVIRONMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1. Understanding the role and responsibility of an engineer</td>
<td>8.8</td>
<td>9.3</td>
<td>9.0</td>
</tr>
<tr>
<td>4.2. Availability of entrepreneurial and business initiative</td>
<td>8.6</td>
<td>9.0</td>
<td>7.7</td>
</tr>
<tr>
<td>4.3. Ability to analyze the process, evaluate the results of the work, plan the activities of subdivision</td>
<td>8.8</td>
<td>8.8</td>
<td>8.7</td>
</tr>
<tr>
<td>4.4. Readiness to participate in the design of technical tools, technological processes and production systems</td>
<td>8.6</td>
<td>8.6</td>
<td>8.5</td>
</tr>
<tr>
<td>4.5. Ability to organize the production process and ensure compliance with the requirements of safety engineering and sanitation</td>
<td>8.9</td>
<td>8.9</td>
<td>8.2</td>
</tr>
<tr>
<td>4.6. Readiness to operate production machines, process equipment and systems</td>
<td>8.9</td>
<td>8.7</td>
<td>9.1</td>
</tr>
</tbody>
</table>
4.7. Ability to organize a team to perform production tasks efficiently and on time

| 4.8. Ability to carry out procedures for testing, verification and certification of products and production facilities |
| 4.9. Ability to use standard technologies of maintenance, repair and restoration of worn-out parts of machines and electrical equipment |
| 4.10. Personnel training in the use of devices, mechanisms, technologies, models and systems |
| 4.11. Ability to complete the life cycle and recycle products and wastes |
| 4.12. Ability to use modern methods of assembling, adjustment of machines and installations |
| 4.13. Innovation - from concept, design, production, to the launch of new products and services on the market |
| 4.14. Demonstration of engineering entrepreneurship skills |

As a result of processing the obtained data, it is possible to compile the following list of attributes, which are the most demanded by employers in the agrarian region of southern Russia, and as a result, often mentioned in the survey.

The ranked list of the first 10 graduates’ attributes that are most significant for employers consists of such characteristics as:

- Operational thinking;
- Demonstration of engineering entrepreneurship skills;
- In-depth knowledge of the basics of engineering, methods and tools;
- Innovation – from concept, design, production, to the launch of new products and services on the market;
- Readiness to operate production machines, process equipment and systems;
- Ability to manage a team;
- Understanding the role and responsibility of an engineer;
- Ability to use modern methods of assembling, adjustment of machines and installations;
- Ability to carry out procedures for testing, verification and certification of products and production facilities;
- Personnel training in the use of devices, mechanisms, technologies, models and systems;

Academic teaching staff of this educational program sees priorities in attributes differently:

- Understanding the role and responsibility of an engineer;
- In-depth knowledge of the basics of engineering, methods and tools;
- Availability of entrepreneurial and business initiative;
- Key knowledge of engineering fundamentals;
- Operational thinking;
- Ability to manage a team;
• Ability to organize the production process and ensure compliance with the requirements of safety engineering and sanitation;
• Ability to analyze the process, evaluate the results of the work, plan the activities of subdivision;
• Ability to organize a team to perform production tasks efficiently and on time;
• Ability to use standard technologies of maintenance, repair and restoration of worn-out parts of machines and electrical equipment;

The ranking of answers that determine the vision of a set of actual attributes by students is represented by the following characteristics:
• In-depth knowledge of the basics of engineering, methods and tools;
• Ability to organize a team to perform production tasks efficiently and on time;
• Ability to carry out effective interaction with people around;
• Ability to manage a team;
• Operational thinking;
• Ability to organize the production process and ensure compliance with the requirements of safety engineering and sanitation;

The ranking of answers that determine the vision of a set of actual attributes by students is represented by the following characteristics:
• Readiness to operate production machines, process equipment and systems;
• Key knowledge of engineering fundamentals;
• Understanding the role and responsibility of an engineer;
• Ability to analyze the process, evaluate the results of the work, plan the activities of subdivision.

5. DISCUSSION AND CONCLUSIONS
Analysis of the ranking of the importance of learning outcomes by different categories of stakeholders has shown that for employers, academic-teaching staff and students, the first three significant ones include in-depth knowledge of the fundamentals of engineering, methods and tools. Students put this result in the first place, lectures - in the second, employers – in the third. In addition, in the top five of the most significant, operational thinking was included by all categories of stakeholders. Employers put this result in the first place, and lectures and students – in fifth place.

In general, it can be said that the degree of similarity of the ranked variation series is higher among lectures and students. Employers have the greatest differences compared to other categories of stakeholders.

Thus, a comparative analysis of the expectations of stakeholders and the characteristics of implemented educational programs of higher education for the training of engineers in the agricultural sector of production has shown the need to consolidate the disciplinary units into educational modules, strengthen project training and develop entrepreneurial competencies.

6. RECOMMENDATIONS AND STUDY PERSPECTIVES
The chosen vector of updating the educational engineering programs in accordance with the CDIO entails a large-scale modernization of the educational activities of the university, aimed at creating a personality-oriented educational environment, developing educational programs of a new generation, developing academic autonomy and responsibility of students, improving the skills of lectures and academic staff [10–14].
REFERENCES


