FACULTY DEVELOPMENT IN THE IMPLEMENTATION OF CDIO CONCEPT AT SIBFU

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ABSTRACT

The paper considers the problem of preparing a human resource for the implementation of the educational program in the CDIO ideology at the Siberian Federal University (SibFU). The training of engineers in the concept of the CDIO approach determines the need in qualified pedagogical staff with the developed professional and pedagogical competencies, teaching skills, proficiency in applying active teaching methods and understanding the essence of the forthcoming changes. The paper describes the experience of SibFU in faculty teaching competence development focused on the methodology of working-out of the teachers' training program and based on the study and identification of the qualification gaps of the teachers and educational engineers. The focus group of the study is the University teachers and educational engineers who have been implemented the educational program "Metallurgy" in the CDIO ideology at SibFU, and the goal is to substantiate and develop the structure and content of the educational engineers and teachers' training program the learning outcomes of which are focused on eliminating the identified qualification gaps. Based on the suggested qualification functions of the educational engineers who have been implemented the program "Metallurgy" in the CDIO ideology at SibFU, the authors propose the idea of training teachers through a specially developed training program and monitoring activities of the educational process performed by the university managers, external experts, and employers.

KEYWORDS

Teachers' training program, qualification gaps and functions, educational program "Metallurgy", educational engineers, Standards: 9, 10.

INTRODUCTION

The implementation of the international initiative CDIO which defines the new strategy of engineering education requires its resource support, first of all the human resource – teaching staff. The guidelines for the training of engineers determine the need for rethinking engineering education, introducing real engineering practice in the educational process, developing abilities and willingness in students to conceive, design, implement and operate complex engineering systems, applying the principles of sustainable development. These guidelines also change the request for teaching staff (teachers, educational engineers, academic managers, etc.) – those people who have been implemented the CDIO approach at the SibFU. Moreover, constant changing of the surrounding world, techniques and technologies determines the problem of lifelong learning in the professional sphere adequately defining new requirements for the training of the University teachers, their continuous professional development.

BACKGROUND INFORMATION

In the process of implementing the educational program "Metallurgy" at the Siberian Federal University, a system for enhancing faculty teaching competence has been developed and introduced for four years of the program's implementation. The principles of the system for enhancing faculty teaching competence are:

- continuity of the process of teachers' training throughout the period of the implementation of the educational program, which allows consider the process of training future engineers of the certain year of study holistically, systematically, reflexively;
- synchronicity of the problems considered in the teachers' competence development program to the problems of the implemented curriculum of the educational program "Metallurgy", which increases the motivation of the teachers and provokes personal significance of the modernization and improvement of the educational process;
- practicing "learning by doing" that determines the need for teachers to present products of their activities for team expertise by project participants;
- focusing of the educational process of teachers' training on the formation of teachers' competencies in the integration of educational areas and the development of integrated tasks (Standards: 3, 7); organization and support of project activities of the students (Standards: 4, 5); effective use of active teaching methods (problem thinking, brainstorming, discussion, debates, case studies, project methods, role plays, etc.) (Standard 8) (Osipova et al., 2017).

Table 1 shows the structure and the results of teachers' training program at SibFU of different years of implementation.

Table 1. The Structure of Teachers' Training System at SibFU

Year of implementation/ Academic hours	The name of the training program	Learning outcomes
2013-2014 / 72	Innovative education in the ideology of CDIO Initiative	Understanding the trends in engineering education in modern world. The concept of the competence-based and CDIO approaches. Updating of theoretical knowledge about modern pedagogical bases of educational process.
2013-2014 / 72	Learning and teaching support material for the educational program "Metallurgy" in accordance with CDIO Standards	Formation of the teachers' competence in designing and implementing the productive learning in teaching the discipline. Development of methodological and content support for the educational process in the CDIO concept (for a specific discipline). Development of visual aids (mental maps, chart schemes, info graphics, algorithms, etc.), demonstrating theoretical knowledge about modern technologies, methods and forms of teaching, ways of designing the educational process.
2014-2015 / 72	Managing the implementation of the innovative educational program "Metallurgy" in accordance with the CDIO ideology	Determination of the monitor actions on the educational process in the CDIO ideology based of its monitoring. Formation of the ability to design a self-development program based on the reflection of personal pedagogical experience and the experience of other teachers.
2015-2016 / 144	The development of stakeholders' competences in the context of the	Implementation of active learning techniques. Reflection of the received pedagogical experience, revealing of the effective teaching techniques for the organization and

	implementation of the educational program “Metallurgy” in the CDIO ideology	implementation of the educational process. Defining the lack of experience and knowledge in using effective teaching techniques and the development of a self-development program in the ideology of reverse design: purpose (expected result of self-development) → ways of measuring it (confirmation) → topical issues of self-development → technologies used in self-development.
2016-2017 / 144	Assessment tools for the educational program “Metallurgy” implemented in the CDIO ideology	The rationale for the graduate's competence model in the descriptor format as the basis for the development of the detailed assessment system.

According to the faculty staff opinion, one of the most difficult teachers’ training programs has appeared to be – “Learning and teaching support material for the educational program "Metallurgy" in accordance with CDIO Standards” therefor it is described below in more details. It consists of several modules:

1. Pedagogical system. Components. Components’ content. The purpose of education/training. Content of the disciplines. Organizational forms and pedagogical technologies. Criteria of practicability of a choice of forms, technologies and monitoring of education/training.
2. Structure and content of methodological support of the discipline. Requirements for educational and methodological complex of the discipline.
3. Requirements of CDIO Standards for the methodological support of the educational program.
4. Presentation of samples of methodological support of various types of educational activities of students in accordance with CDIO Standards (lectures, practice, seminars, laboratory works, project work, etc.).
5. Maintenance and supervision of student’s individual work in accordance with CDIO Standards 1, 4. Organizational forms and supporting activities, including project work of the students.
6. Methodological support of the course “Introduction to Engineering” in accordance with CDIO Standards: Problem solving; Scientific basis of intellectual activity; Information resources; System and critical thinking.
7. Methodological support of the system of pre-university training in accordance with the CDIO Standard 1: Organizational and content activities to motivate enrollees to become metallurgists; Educational program of fundamental pre-university training; Psychological and pedagogical support of professional identity of enrollees.
8. Methodical support of the system of continuous formation of students’ project competence in the process of their professional development in accordance with CDIO Standard 4.

For the most University teachers and educational engineers the described program appeared to be quite a challenge and 60% of the faculty staff quit the educational program during the first year of its implementation. The rest 40% of the remaining staff has become a project team, who is ready to carry out a variety of activities: implementation of discipline in the CDIO concept, support students at project work, prepare students’ teams for international engineering competitions and events, etc.

This paper shows the methodology and the results for the system of teachers’ training at SibFU. The focus group for the study was the University teachers and educational engineers implementing the educational program "Metallurgy".

The goal of the study was to substantiate and develop the structure and content of the educational engineers and teachers’ training program the learning outcomes of which were

focused on eliminating their qualification gaps. Achieving this goal implies solving the following tasks:

- compilation of the required list of professional and pedagogical competences (qualification functions) of educational engineers needed for reaching new engineering education goals;
- identification of their qualification gaps, negotiation and coordination with the management of the educational institution and program the educational results of the suggested teachers' training program.

Also, the applied research task was the development of diagnostic tools such as questionnaires for identifying qualification gaps, self-assessment questionnaires, expert surveys for educational managers.

METHODS

The research methodology is represented by a polyparadigmatic approach that includes: a systematic approach in training engineers; activity-competence approach which defines the teacher as an evolving, acting, reflective personality; a synergetic approach in the context of openness and social responsibility of engineering education, networking and integration of higher engineering education and industry.

The following methods were used:

- theoretical methods – an analysis of the Professional Standard of the teacher of higher education and CDIO Standards has been carried out. In the analysis we focused our attention on the CDIO Standards due to the specific organization of the educational process on the program "Metallurgy": strengthening the practical part of the training, and introducing problem-solving, project-based, integrated training techniques that require the educational engineer to master specific pedagogical skills. These skills were summed up into four qualification functions of the educational engineer of CDIO. They integrate engineering and pedagogical skills and abilities.
- practical methods – an expert survey of the suggested four qualification functions of the educational engineers has been carried out. The qualification functions and gaps of the educational engineers were specified and ranked. Also, the educational engineers were interviewed to clarify their opinions on the content, significance and intensity of the suggested teachers' training program on the development of the identified qualification functions.
- empirical methods – the results of expert surveys and questionnaire have been summed up. The matrix of qualification functions of educational engineers has been drawn up where the most/least important qualification functions have been identified.

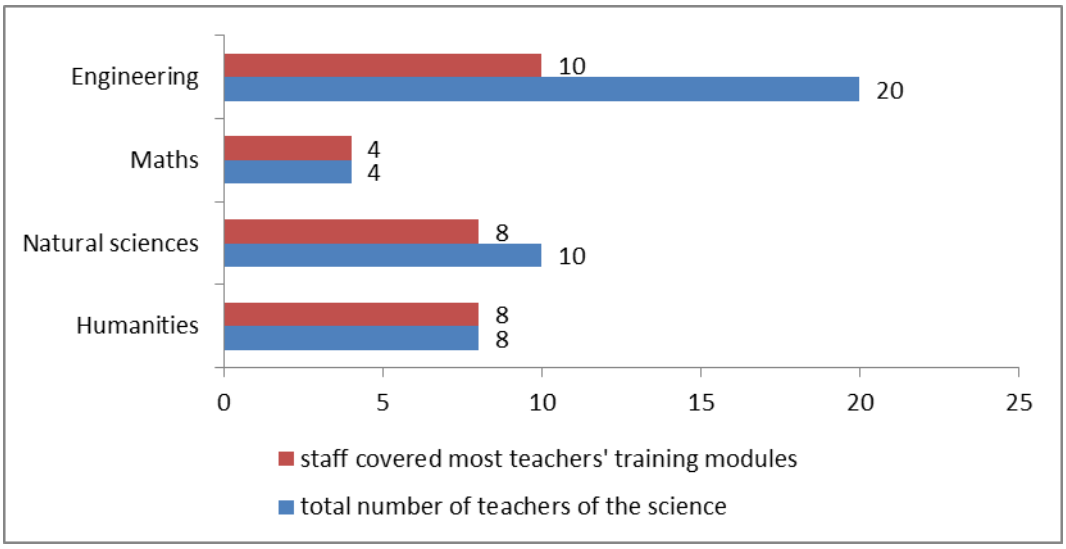
RESULTS AND DISCUSSIONS

The educational program "Metallurgy" has been implemented by 3 different categories of staff members:

1. Administrative staff: the head of the institute, the head of the educational program, the academic managers of the program, the head of the internship, the scientific supervisor of the educational program - 5 people.
2. Support staff: engineers, methodical consultants - 4 people.
3. University teachers and educational engineers: the humanitarian module - 8 teachers; the natural-science module - 10 teachers, Mathematics – 4 teachers; the engineering module - 20 educational engineers, 10 of whom are project managers as well.

Figure 1 shows the number of faculty members of each science group who has covered most training modules of the described teachers' training program.

Figure 1. Data on the Number of Participants of the Teachers' Training Program



As data show the most active participants of the program were the teachers of Humanities, Mathematics and Natural Sciences. As a result the programs of the disciples have been redesigned based on CDIO approach, competence-based approach and the learning outcomes have been demonstrated not only at the discipline exam but also during the project work. All the changes have also influenced curriculum redesign, for example the number of lecture hours of some disciplines has been reduced in favor of increasing practice and project work. Some disciplines have either become the modules of Major or changed the format into STEM games, thus the amount of disciplines in total have been reduced. What is more, the introduction of new active teaching methods which imply the development of personal and interpersonal competences have revealed the need to include some new Electives and Minors in the educational program such as Technical English, Business English, Teambuilding and Leadership, Technical Cases, Project Management, Engineering Ethics, etc. as well as adaptive courses for some disciplines.

Qualification Functions

As a result, the professional competencies of educational engineers implementing "Metallurgy" program in CDIO approach at SibFU were revealed and after the processing the questionnaires and surveys the Matrix of qualification gaps on four qualification functions was presented (Figure 2).

Figure 2. Matrix of Qualification Gaps on Four Qualification Functions

		Qualification Function Level (teachers' self-assessment):		
		low (0-2)	middle (2.1-3.5)	high (3.6-5)
Qualification Function (employers'	high (3.6-5)	**QF 1**	**QF 2 QF 4**	
	middle (2.1-3.5)		**QF 3**	

		Qualification Function Level (teachers' self-assessment):		
		low (0-2)	middle (2.1-3.5)	high (3.6-5)
	low (0-2)			

One qualification function (qualification function 1) was highly significant for the employer, but formed at a low level among the teaching staff of the educational program, two qualification functions (qualification functions 2, 4) are also highly estimated by managers, but their level of proficiency among teachers is average.

We suggest the following interpretations of the identified qualification functions:

- qualification function 1 (QF 1) – implementation of quasi-engineering activities in the educational process based on the topical practical experience of a particular industrial sector;
- qualification function 2 (QF 2) – management of student projects for the specific tasks of the employer, industry and learning outcomes;
- qualification function 3 (QF 3) – team work on the development of integrated tasks focused on learning outcomes of the discipline, educational and engineering activities that meet the specific features of the innovative educational environment;
- qualification function 4 (QF 4) – organization of interactive cognitive-reflective activities based on active teaching methods through the use of round-table discussions, debates, visualization, revealing an understanding of the content of the discipline being studied.

Teacher and Employer Assessment

The red sector of the matrix demonstrates the qualification function of low level of competence of respondents (the average score based on the results of the questionnaire is in the range of 0-2 points) but of high importance by the employer (average score is 3.6-5 points). This qualification function (QF1) is considered to be the most significant and priority in terms of mastering during the teachers' training program.

The blue sector of the matrix demonstrates the qualification functions of the average level of competence of respondents (average score is 2.1-3.5 points) and of high level of significance by employers. The formation of a good level of proficiency of the stated qualification functions (QF 2, 4) during the teachers' training course is considered to be of high importance for the educational program, but their priority is a bit lower.

The orange sector demonstrates the qualification function with the average level of competence (range – 2.1-3.5 points) and importance by employers. The formation of the stated qualification function (QF 3) during the teachers' training course is considered to be not so significant.

Taking into account the answers of the teachers in interviewing and questioning, the following conclusions can be made:

- Qualification function 1 is the most significant from the point of view of the employer but of low level of proficiency of respondents that requires the creation and organization of special conditions for the systematic acquisition of experience in relevant engineering activities that can be implemented in cooperation with partner enterprises.
- Qualification function 2 is also significant for the employer, and the teachers' level of formation of this function is average. In interviewing, teachers as well as managers highly value the significance of this function; moreover they believe that the "product" result of the project is more important than the "educational" result. University teachers consider it is efficient to initiate a project for specific tasks of the employer, i.e. to decrease the number of educational projects and increase the amount of industry projects to form the required level of professional engineering competence of the graduate.

- Qualification function 3 turned out to be "average" both in the assessment of the importance of the employers and in the level of its formation in the teaching staff. Some teachers believe that an integrated task can be developed only by a specialist with real industrial experience in the theoretical and practical product design and implementation. Other teachers believe that the integration of disciplines and learning outcomes will allow controlling the quality and forming a willingness to use general fundamental engineering knowledge.
- Qualification function 4 is significant for the employer, but the level of formation of this function of the teaching staff is average. Interviewing show that the teachers see the use of active technologies to be reasonable only when implementing the project activity and obtaining practical professional skills, they realize the importance of using active technologies as a way to increase the motivation for learning, but they have difficulties in implementing their own disciplines in active methods.

Training Modules

We have developed an advanced training program considering three qualification functions described above (QF 1, 2, 4). Qualification function 3 hasn't been included in the teachers' training program due to the average evaluation of its importance by the employer and the average level of proficiency of this function by teachers.
The structure of the teachers' training program is developed in accordance with the identified qualification functions. The learning suggests full-time participation ("plunge"), since a professional interactive educational environment, teamwork, active learning and reflection is needed to develop the identified qualification functions. The program is represented by three modules:
The first module implies cooperation and interaction with partner enterprises. The result of the training are considered to be "packaging" of the industrial tasks in the context of obtaining an educational product. The form of the training – training at the enterprise.
The second module proposes the implementation of project activities, the result of which is supposed to be the development of a project passport and the implementation of certain stages of a particular project.
The third module involves mastering active technologies. The result of the module suggests that the educational engineers will be able to choose the appropriate active methods of teaching relevant to the purpose, content, learning outcomes of the particular lesson.

CONCLUSIONS

The presented experience of training teachers and educational engineers who implement engineering education in the context of CDIO ideology at SibFU is quite universal in terms of organizing the process of teachers' professional development by comparing the teachers' available and required level of competence in accordance with the qualification functions defined by the Professional Standard, CDIO Standards and the employer.

REFERENCES

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