

# STAKEHOLDERS' EVALUATION OF LEARNING OUTCOMES IN EDUCATIONAL PROGRAMS IMPROVEMENT

Elena A. Muratova, Marina S. Tayurskaya

National Research Tomsk Polytechnic University

## ABSTRACT

The paper shows the results of questionnaires' surveys conducted by Tomsk Polytechnic University relating to its Bachelor Programs in Chemical Technology and Electrical Engineering. With regard to the topics of CDIO Syllabus under 2 layers of detail (X.X.), stakeholders including employers, alumni, professors and students have been asked to what level of attainment the programme learning outcomes should strive for, and compare this with what level they evaluate is achieved in the current curricula. We compare data received on each programme and also data of programmes among themselves. The results of the surveys were used in:

- specifying the levels of learning outcomes to be achieved in each programme,
- promotion of programme/ module learning outcomes adjustment,
- inspiring faculty and programme designers "to look about" and to cooperate closely with industry,
- involving employers into constructive dialogue on what learning outcomes graduates have to possess.

The paper reviews the methodology and procedure of questioning and describes TPU policy in engineering programmes improvement.

## KEYWORDS

CDIO Syllabus, learning outcomes evaluation, level of proficiency, stakeholders surveys, improvement of educational programmes.

## INTRODUCTION

Preparation of graduates competitive on the global labor market and design of attractive engineering educational programmes are priority development areas of National Research Tomsk Polytechnic University (TPU). Hence, the approval and alignment of educational programmes with the requirements of the employer and international accreditation agencies is a necessary stage in their design.

TPU joined CDIO Initiative in 2011 and started modernizing Bachelor's Programs, including adjustment of their objectives and learning outcomes in compliance with CDIO Concept [1]. One of the current tasks includes quality monitoring of engineering educational programmes, introduction of educational program proficiency assessment mechanism. Alignment of educational programmes with the requirements of employers and international accreditation agencies is a necessary stage in their design and an integral part of their improvement.

CDIO Collaborators are actively applying various questionnaires and interviews for stakeholders to define the expected level of learning outcomes proficiency according to topics of CDIO Syllabus [2], as well as to develop their own lists of learning outcomes based on CDIO Syllabus taking into account requirements of professional communities and industry representatives [3-7].

TPU also holds regular surveys of employers and graduates, the results of which are used for

improvement of educational programmes. However, the results of such surveys were mainly focused on the evaluation of the acquired level of learning outcomes proficiency, while students and faculty members were outside the scope of the survey. Thus, the authors suggest learning outcomes evaluation mechanism, which allows to get comparable expert evaluation of major stakeholders with regard to both the desired (expected) level of learning outcomes and the acquired level in the framework of the existing curriculum.

The mechanism is based on the results of the questionnaire, which posed the following tasks:

- identification of the desired level of learning outcomes proficiency expected by stakeholders, which will allow to formulate learning outcomes more precisely;
- identification of the acquired level of learning outcomes proficiency. Comparison of the expected and acquired levels will demonstrate the level of satisfaction/dissatisfaction of various groups of stakeholders with the quality of educational programmes;
- identification of educational programme learning outcomes that have the most deviations in the assessment between the expected and acquired levels (highest discrepancy) for further analysis of processes within the educational programme leading to the achievement of learning outcomes [8];
- comparative analysis of questionnaire results between educational programmes needed to identify systematic problems and to plan university activities aimed at change of university educational environment.

This paper describes questionnaire procedure and survey results held at TPU in 2013, covering major stakeholders of two educational programmes - Bachelor Programs in Chemical Technology (CT) and Electrical Engineering (EE).

## **DESCRIPTION OF QUESTIONNAIRE PROCEDURE**

The following categories of stakeholders took part in the survey - 2 Bachelor Programmes in Chemical Technology and Electrical Engineering:

- 3-4<sup>th</sup> year students,
- faculty of the programme (BEP head, heads of profiles, projects, course works and final qualification papers, practical training),
- alumni,
- employers.

The questionnaire includes the list of CDIO Syllabus evaluated learning outcomes. The respondents are offered to define the desired (expected) level of learning outcomes proficiency necessary for successful start of graduates' professional activity and to evaluate the acquired level of learning outcomes proficiency for the existing programmes. Learning outcomes, which were evaluated by respondents, were taken from CDIO Syllabus topics under 2 (X.X.) layers of detail (Appendix 1).

To evaluate the desired and the acquired levels of proficiency for every CDIO Syllabus topic the authors used a scale based on summative scale (Likert scale). Every level of the scale is related to the level of educational objectives of Feisel-Schmitz taxonomy (1- Define, 2 - Compute, 3 - Explain, 4 - Solve, 5 - Judge), adjusted to engineering activity. This correlation will allow to expand further more the content of learning outcomes during engineering educational programme design (Table 1).

The questionnaire also includes questions specific for every group of stakeholders, which were taken into account in the analysis. Various options for filling in the questionnaires were implied: paper and electronic versions, which allowed supervisors of educational programmes to collect data immediately. Questionnaire results analysis is presented below.

Table 1. Evaluation scale of the expected and achieved levels of learning outcomes proficiency [9].

Point	Level of educational objective (Feisel-Schmitz Taxonomy)	Interpretation from justification view point
5	Judge	To be able to lead the work and bring (suggest) something new
4	Solve	To have practical experience of applying (using) something
3	Explain	To be able to explain and demonstrate to others
2	Compute	To be able to demonstrate and suggest typical solution
1	Define	To have minor experience in execution and participation (demonstration)
0	-	Learning outcome is not developed

### EXPECTED LEVEL OF LEARNING OUTCOMES PROFICIENCY

The expected level of learning outcomes proficiency evaluations by various groups of stakeholders is shown in Figures 1 (for Electrical Engineering) and 2 (for Chemical Technology).

Figures 1-2 show that both graduates and students score the importance of mentioned learning outcomes proficiency higher than other respondents: in most cases their scores of the importance of learning outcomes are higher than those of the employers. The evaluation results of all groups of stakeholders demonstrate that learning outcomes for both programs should be developed at least in compliance with level 3 of the proposed scale (to be able to demonstrate and suggest typical solution), and some learning outcomes – in compliance with level 4 (to have practical experience of applying (using) something). For Chemical Technology at level 4 the following learning outcomes should be developed: 2.1 Analytical reasoning and problem solving, 2.3 System thinking, 2.5 Ethics, equity and other responsibilities, 3.1 Teamwork, 4.7 Leading engineering endeavors. For Electrical Engineering Program 3.2 Communications can be added to the above mentioned learning outcomes.

Despite mentioned in questionnaires close cooperation with enterprises and graduates the scores of the expected level of learning outcomes made by Electrical Engineering Program faculty are “far from reality”. In general, faculty scores of the expected level are one point lower than those of the employers. Thus, faculty members of Electrical Engineering Program underestimate the importance of learning outcomes proficiency and hence, do not take this into account in their disciplines.

Particular attention should be paid to the evaluation of employers since neither learning outcome was ranked higher than 3 (able to demonstrate and suggest typical solution), except for 2.5 Ethics, equity and other responsibilities. For learning outcome 4.8 Entrepreneurship – faculty evaluation is slightly higher than 1, which indicates the fact that students have minor experience in execution and participation (demonstration) of this learning outcome.

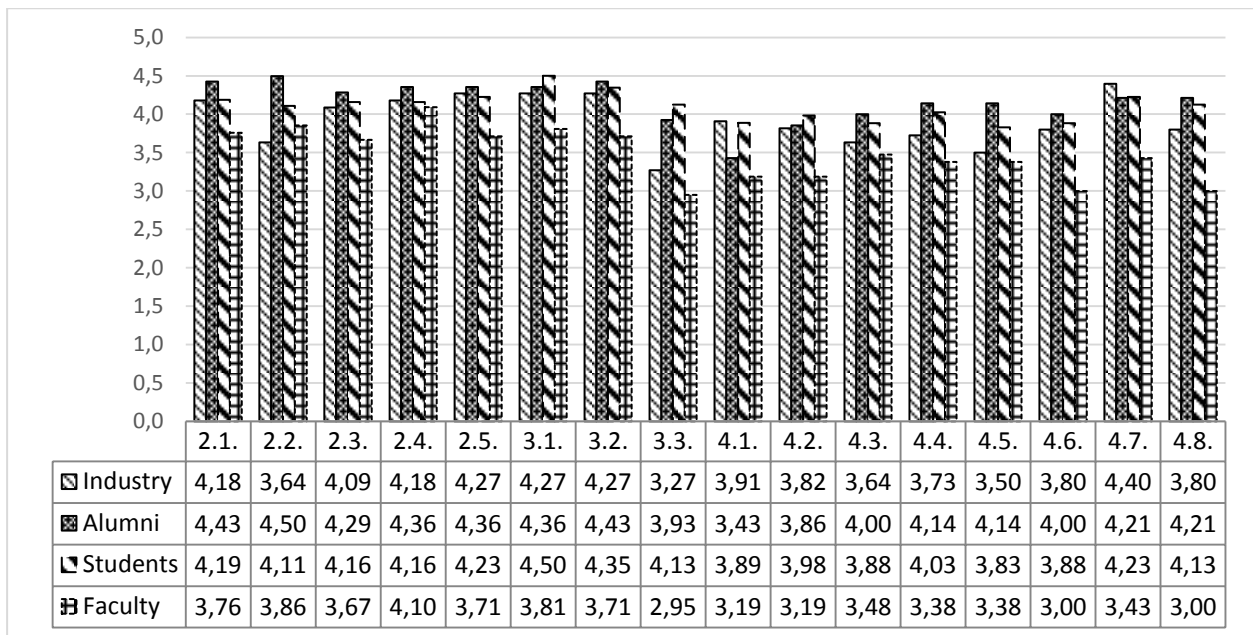


Figure 1. Expected level of proficiency for groups of stakeholders (Electrical Engineering)

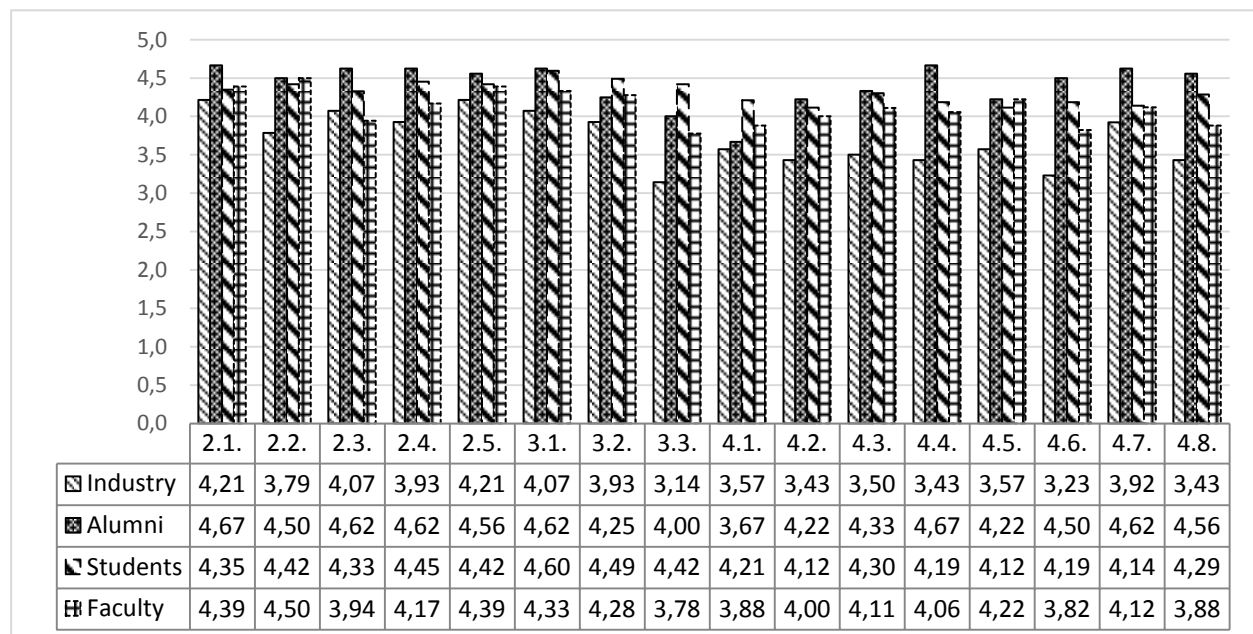


Figure 2. Expected level of proficiency for groups of stakeholders (Chemical Technology)

Stakeholders' survey results are presented in Figures 3-6. Lines show the average expert evaluation of the expected level of learning outcomes proficiency while columns represent the average expert evaluation of their acquired level. The table below the Figure shows number indicators of the average expert evaluations. These diagrams allow to compare the evaluation of the expected and acquired levels of learning outcomes proficiency and to make their comparative studies within programmes.

## EMPLOYER SURVEY RESULTS

11 employers from Electrical Engineering and 14 employers from Chemical Technology took part in the questionnaire. Figure 3 shows employer survey results.

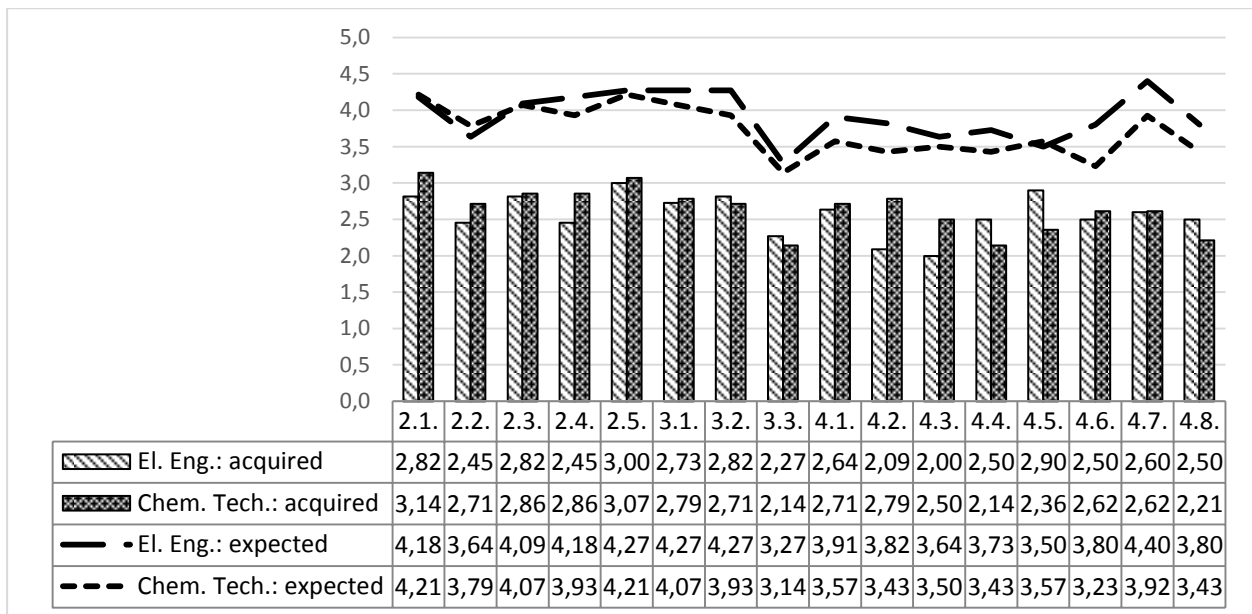


Figure 3. Acquired and expected level of proficiency (evaluated by industry)

In compliance with the Figure 3 the expected level of learning outcomes (listed in CDIO) achievement by graduates is relatively high and on average amounts to 3.71 for Chemical Technology and 3.92 for Electrical Engineering. It is noteworthy that evaluation of the expected level of learning outcomes by the employers of Electrical Engineering is in general slightly higher than those for Chemical Technology. However, expectations of employers of both programmes are almost the same: they highly evaluated the importance of learning outcomes 2.1. Analytical reasoning and problem solving, 2.3. System thinking, 2.5. Ethics, equity and other responsibilities, 3.1. Teamwork, 3.2. Communications and 4.7. Leading engineering endeavors. It should be noted that the importance of learning outcome 2.5. Ethics, equity and other responsibilities is highly scored by employers (more than 4.2), which slightly contradicts Skoltech survey, where the evaluation of this learning outcome by employers was relatively low [6]. The employers perceive learning outcome 3.3. Communications in foreign languages as the least important, which possibly justifies low focus of the labor market on the interaction with foreign partners and lack of employers of foreign industry representatives in the survey.

From employers point of view the acquired level of learning outcomes proficiency leaves much to be desired: the difference between expected and acquired levels of learning outcomes proficiency on average amounts to 1.08 for Chemical Technology and 1.36 for Electrical Engineering. The diagram shows that the level of learning outcomes proficiency among graduates is almost the same for both programs. The exception is the following learning outcomes: 4.2. Enterprise and business context and 4.3. Conceiving, systems engineering and management, where the level of preparation among Chemical Technology graduates is higher, as well as 4.5. Implementing, where the result was developed in the framework of Electrical Engineering program. The highest dissatisfaction of the employers is seen in learning outcome 4.7. Leading engineering endeavors, which shows the biggest difference between the evaluation of the expected and acquired levels of proficiency.

## ALUMNI SURVEY RESULTS

14 graduates of Electrical Engineering and 9 graduates of Chemical Technology took part in the questionnaire. Alumni survey results are shown in Figure 4.

As presented in the Figure 4 graduates in general scored high the importance of developing

all mentioned learning outcomes: the evaluation of learning outcomes importance for Chemical Technology varies from 3.67 to 4.67, and for Electrical Engineering from 3.43 to 4.5, which is higher than employers' evaluation. Thus, graduates of Chemical Technology evaluate the expected level of learning outcomes proficiency slightly higher than the graduates of Electrical Engineering. Below others graduates of both programs evaluate the importance of such learning outcomes as 3.3. Communications in foreign languages, 4.1. External, societal, and environmental context and 4.2. Enterprise and business context.

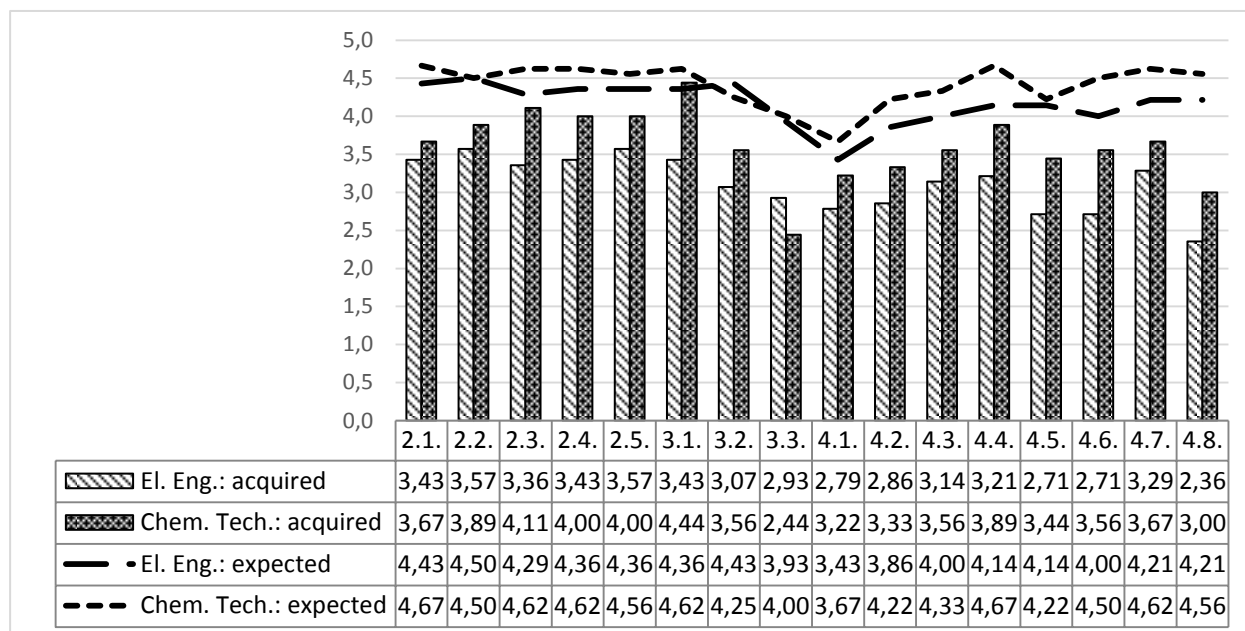


Figure 4. Acquired and expected level of proficiency (evaluated by alumni)

Graduates self-assessment of the acquired level of proficiency with regard to skills and knowledge obtained during studies at TPU is on average one point higher than the evaluation by employers. Thus, the level of satisfaction with learning outcomes of Chemical Technology graduates is higher than Electrical Engineering. Particularly high compared to graduates of Electrical Engineering, the graduates of Chemical Technology program evaluate the level of learning outcomes proficiency: 3.1. Teamwork, 4.5. Implementing and 4.6. Operating. As for learning outcome 3.1. Teamwork, the evaluation of the expected and acquired levels by Chemical Technology graduates is almost the same. The level of learning outcome 3.3. Communications in foreign languages is higher by the evaluation of Electrical Engineering graduates, which might give evidence of their better preparation in foreign languages compared to graduates of Chemical Technology. The biggest difference between expected and acquired levels is seen in learning outcome 4.8. Entrepreneurship for both programs.

## STUDENTS SURVEY RESULTS

58 students of Electrical Engineering and 43 students of Chemical Technology took part in the questionnaire. Figure 5 shows the results of this survey.

The results of the survey show high evaluation of learning outcomes importance by students. Such high indicators most likely prove the fact that students do not really have a clear understanding of the character, content and conditions of their future professional activity. The highest score was given to learning outcome 3.1. Teamwork, which might indicate that senior bachelor students understand the importance of being able to work in a team and use various methods of collaboration. Similar to graduates students of Chemical Technology

ranked the importance of suggested learning outcomes proficiency much higher than students of Electrical Engineering.

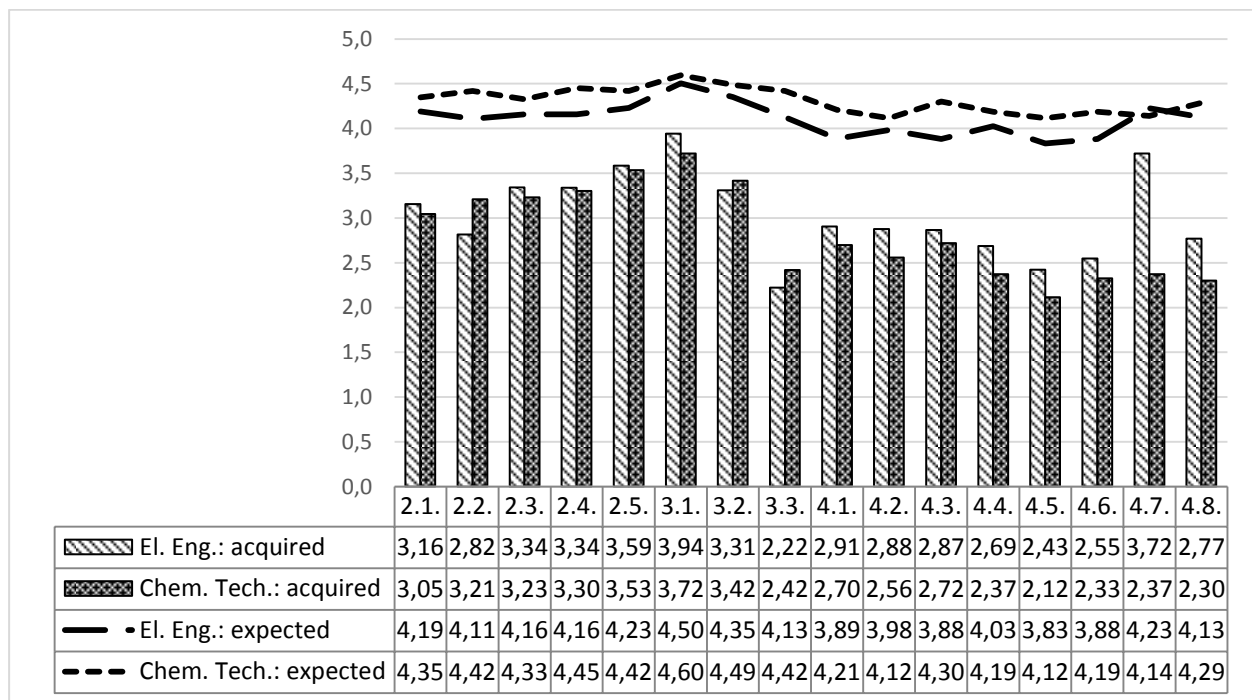


Figure 5. Acquired and expected level of proficiency (evaluated by students)

In general students of both programmes give similar scores to the acquired level of learning outcomes proficiency. The highest score was given to learning outcome 3.1. Teamwork. Graduates also gave high scores to this learning outcome. However, the evaluation by employers and faculty is not that high. Possibly, active social students' relations impacted this high score, while employers and faculty do not take this into account. The lowest scores of the acquired level of learning outcomes were given to 3.3. Communications in foreign languages for Electrical Engineering and 4.5. Implementing for Chemical Technology. An interesting fact that compared to other groups of respondents students of Electrical Engineering give quite high evaluation to the acquired level of learning outcome 4.7. Leading engineering endeavors.

## FACULTY SURVEY RESULTS

21 respondents of Electrical Engineering and 18 respondents of Chemical Technology took part in the survey. 90% of the faculty members under the survey are teachers of professional disciplines taught at senior years of study. 76% of respondents indicated that they keep relations with graduates of the educational program. Almost all teachers cooperate with industry representatives in various aspects of professional activity, including joint work on organizing students practical training (38%) and visits to enterprises (43%); professional development on the job (at the enterprise) (48%); participation in different events (conferences, workshops) held by enterprises (43%); organization of meetings with industry representatives (29%) and meetings to get alignment on discipline content (29%). Faculty survey results are presented in Figure 6.

The Figure 6 shows that based on faculty evaluation the acquired level of graduates' learning outcomes proficiency is relatively low. The lowest score was given to the acquired level of learning outcome 3.3. Communications in foreign languages for both educational programs. It also shows its minimum importance, especially what concerns graduates of Chemical Technology.

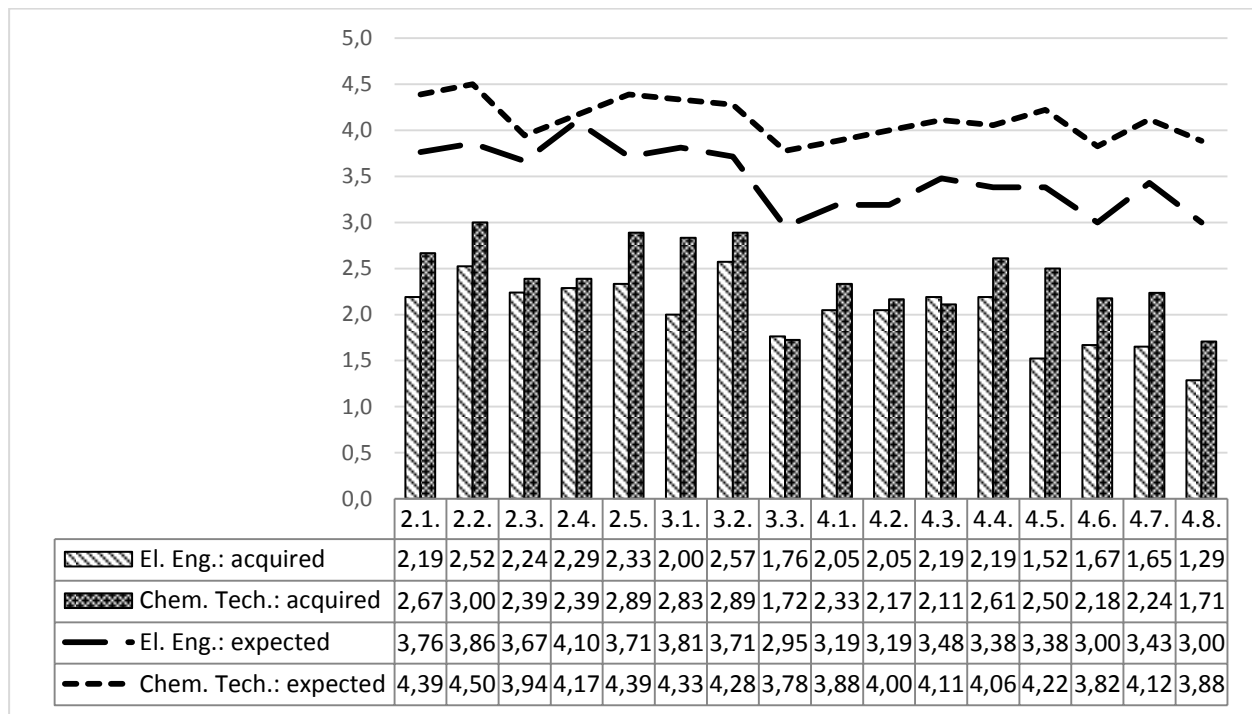


Figure 6. Acquired and expected level of proficiency (evaluated by faculty)

Faculty members of Electrical Engineering and Chemical Technology give different scores to the expected level of learning outcomes proficiency within their programs: such difference between the programs is not observed in evaluations by other groups of stakeholders. In general, teaching staff scored higher the expected level of learning outcomes proficiency for Chemical Technology. Electrical Engineering gained maximum scores for learning outcome 2.2 Experimentation, investigation and knowledge discovery, and for Chemical Technology - 2.4 Attitudes, thought and learning. High importance of such outcomes may indicate theoretical focus of educational programmes, since such learning outcomes as 4.3 Conceiving, systems engineering and management, 4.4 Designing, 4.5 Implementing, and 4.6 Operating are less important to the faculty of both educational programs. However, if we compare expert evaluations of the faculty and the employers of Chemical Technology for the same group of learning outcomes we can say that the faculty gives them (those outcomes) higher scores (on average – 4.05) than the employers (on average – 3.43). By comparing educational programs with each other we can see that the faculty of Chemical Technology scores such outcomes much higher than those of Electrical Engineering, except for learning outcome 4.3 Conceiving, systems engineering and management.

## COMPARATIVE ANALYSIS OF QUESTIONNAIRE RESULTS

Diagrams 3-6 show that stakeholders' assessment of learning outcomes proficiency is lower than the expected level for both programs. Let us define the basic problems common to all programs:

1. Particularly low values (not higher than 2.5 in the used scale) have learning outcomes related to Section 4 of CDIO Syllabus, i.e. there are product and system building skills focused on conceiving, designing, implementing, and operating systems. This justifies theoretical focus of Russian engineering educational programs and lack of students ability to acquire real engineering experience during their study [10].

2. Low scores of the acquired level of learning outcomes proficiency related to 4.7. Leadership and 4.8 Entrepreneurship justify the fact that students have irrelevant experience



of executing and participating (demonstrating) such learning outcomes within the educational programme. This fact can partially be explained by way to design educational programs which existed in Russian universities. The majority of program designers consider learning outcomes related to leadership and entrepreneurship as the ones to be developed within master studies and hence do not imply their proficiency within bachelor's programmes.

3. High stakeholders' dissatisfaction with learning outcomes related to CDIO Syllabus 3.3. Communications in foreign languages is the reason of biggest concern. This shows inefficiency of students' language training programs and university resources for their implementation. High performance of students in foreign languages against high level of students' and graduates' dissatisfaction with learning outcomes demonstrate the need to review not only the content and learning technologies for this discipline but also the adjustment of assessment techniques and methods of students learning outcomes achievement.

The problems identified above are common for both programs and require particular attention, decision-making and monitoring at the level of university administration.

## CONCLUSION

It was identified that the acquired level of CDIO Syllabus learning outcomes proficiency for Electrical Engineering and Chemical Technology programmes from the point of view of different stakeholders (students, graduates, faculty and employers) do not match the level of learning outcomes expected by stakeholders.

Evaluation of the expected level of learning outcomes proficiency of the programme was done by various categories of stakeholders (students, alumni, faculty and employers). Differences in the scores of all stakeholders for Electrical Engineering and Chemical Technology programmes were identified. Results of the survey are shared with programmes leadership and designers, which should set the appropriate level of every learning outcome and make adjustments in the content of educational programs if necessary.

The degree of stakeholders' dissatisfaction with the acquired level of learning outcomes proficiency was also identified, which will allow to develop an action plan aimed at the improvement of the educational programme.

Used mechanism of learning outcomes assessment allowed to identify systematic problems in learning outcomes development and will serve the basis for planning university educational policy and strategy.

Questionnaire results ensure informative feedback concerning quality of implemented educational programmes and serve the basis for their continuous improvement.

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## BIOGRAPHICAL INFORMATION

**Elena A. Muratova**, Ph. D., Director of the Education Quality Assurance Centre of Tomsk Polytechnic University, Russia. Her current research focuses on adaptation, development, and implementation of new technologies of students learning outcomes' achievement assessment.

**Marina S. Tayurskaya**, Deputy Director of the Center for International Academic Programs of Tomsk Polytechnic University, Russia. She works on organization of academic mobility programs for students and faculty, development of cooperative (incl. double-, dual-, joint degree) programs. Her current PhD research is aimed at adoption and adaptation of CDIO concept in Russian engineering universities.

### **Corresponding author**

Mrs. Marina S. Tayurskaya  
Tomsk Polytechnic University  
30, Lenin Ave., 634050, Tomsk, Russian  
Federation  
+7 3822 555604, [mst@tpu.ru](mailto:mst@tpu.ru)



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**The CDIO Syllabus v2.0 under 2 layers (X.X.) of details**

**2 PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES**

- 2.1 Analytical reasoning and problem solving.
- 2.2 Experimentation, investigation and knowledge discovery.
- 2.3 System thinking.
- 2.4 Attitudes, thought and learning.
- 2.5 Ethics, equity and other responsibilities.

**3 INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION**

- 3.1 Teamwork.
- 3.2 Communications.
- 3.3 Communications in foreign languages.

**4 CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE, SOCIETAL AND ENVIRONMENTAL CONTEXT – THE INNOVATION PROCESS**

- 4.1 External, societal, and environmental context.
- 4.2 Enterprise and business context.
- 4.3 Conceiving, systems engineering and management.
- 4.4 Designing.
- 4.5 Implementing.
- 4.6 Operating.
- 4.7 Leading engineering endeavors.
- 4.8 Entrepreneurship.