The impact of engineering students’ communication behavior on the teams’ performance (case study: Chemical process engineering classes)

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Abstract. The activity of modern engineer requires the ability to work in a multi-discipline team and the ability to hand over clearly the professional information to the other team members who are specialists from another field. Therefore, according to the researches graduates from engineering universities lack skills of business communication and team work interaction. That is why the organization of work of future engineers in small groups fulfilling different team roles and the use of moderation methods for the achievement of the effective team cooperation will enable the achievement of the goal of necessary cooperation skills development.

1. Introduction

The current direction of Chemical Engineering [1-8] required highly-qualified employees who are master of professional activity, team working and project management.

In accordance with the abovementioned we introduce small groups at “Chemical Engineering” classes as they provide the context for development of such universal engineering competencies as “the ability to carry out social interaction and fulfill his role in the team” which supposes the future engineer’s “knowledge of the basic techniques and norms of social interaction; principles of leadership and team building; technologies of interpersonal and group communication in business interaction” and “the knowledge how to establish and maintain contacts that ensure successful work in a team; apply the basic methods and norms of social interaction to fulfill their role and interaction within the team”. Small groups also provide development of future engineer skills of social interaction and teamwork, distribution and implementation of the optimal role in the team.

As studies of American scientists show, the lack of communication skills of engineers, both among themselves and with colleagues from other fields, can lead to major disasters, such as the crash of a spaceship worth 125 million dollars [9]. Such incidents and the general dissatisfaction of industrial employers with non-technical professional skills of engineers such as communication and teamwork skills led to the fact that in 1996 ABET [10] (Official organization in the United States that accredits educational programs of colleges and universities in engineering fields) Engineering Criteria 2000 (EC2000) was created. Two important key educational competencies for engineers listed in EC2000...
were the ability to work in multidisciplinary teams and advanced communication skills. ABET still indicates these educational competencies as key, which shows their special significance.

2. Object, subject and purpose of research
Object of research is the professional training of engineers majoring in technical disciplines, namely in «Chemical Process Engineering». Subject of research is pedagogical conditions for the development of the skills of future engineers in multidisciplinary, collaborative teams in the process of professional training. Purpose is the development of methods for communication skills development among students in a multidisciplinary team.

3. Hypothesis
Development of students' professionally significant skills in a team during discipline "Processes and devices of chemical technology" study will be effective with the following organizational and pedagogical conditions [11-35]:

- Organization of training in small groups (for doing laboratory work, alternating role-playing duties typical for an engineer in an innovative environment and solving creative problems based on professional situations).
- Organization of training in real production conditions at "NizhnekamskNeftekhim", "Kazanorgsintez", "Gazprom" and other refineries.
- When students calculate and design different processes of real production, included in one technological scheme, on the basis of teams interaction, which results in mutual learning (course project).

4. Research methods
The methods are as follows:

- Theoretical analysis of the research subject and problem, teaching modeling, theoretical generalization of research results.
- Theories of systemic and personality-activity approaches to the study of pedagogical phenomena.
- Empirical methods: statistical methods of processing and interpreting the result that are included observation, questionnaire, testing.

The detailed description of hypothesis is as follows:
It is necessary to form small groups when conducting laboratory classes, since the academic group consists of 20-25 students and all 20-25 students should participate in laboratory experiments, the group is divided into 4 subgroups of 5-7 students. Thus, we get a collaborative team that conducts an experiment, makes the necessary calculations, compares experimental and calculated data, draws conclusions. The final stage of each laboratory work is also done in a team.

The relevance of industrial practice is to gain practical skills. As a rule, the purpose of practice is to monitor the received material and its further processing. The resulting material should be analyzed and systematized. Also, the purpose of the practice is to consolidate the theoretical knowledge acquired at the university. Depending on the major, the following goals can be set for the student:

- To systematize and bring together the theoretical knowledge obtained at the university along with practical experience.
- During practice, the student must rationally organize his skills in the chosen profession.

In order to achieve this, you need to solve the following tasks:
• Collect more detailed information about the activities of the organization.
• Study its structure, as well as functional features.
• Get acquainted with the activities of individual units.

Moreover, in order to complete each task, you need to carry out a number of manipulations. For example, familiarization with the organization will be incomplete if you do not study the available documentation, including regulations, bylaws, and so on. Acquaintance with a specific activity occurs through the study of certain professional functions.

The course project is the final stage of training at "Chemical Process Engineering" classes. Based on the competencies gained in laboratory classes and seminars, students are given a task - to calculate and design of a real industrial production process. It is also necessary to divide the group into 4 teams, each of which is responsible for the equipment in which the process is carried out.

At the same time, within the subgroup, students perform:

• Technological calculation - the calculation of the height, diameter or surface of the equipment;
• Hydraulic calculation - at this stage students get the understanding that knowledge of the resistance of the apparatus is necessary for the technical and economic calculation;
• Optimization of the process - at this stage students use the software of the department;
• Mechanical calculation students perform the strength calculations.

Further, within the framework of the whole academic group, a technological scheme is formed. It includes the devices that have been calculated in teams. At the same time, the technological scheme is discussed by teams and students and rational technological modes of the obtained technological scheme are formed.

5. Results
During the research, the following results were obtained.

75% of students believe that the creation of a strong team is influenced by the conditions created in the university (platforms, incentives, classes), of which more than 47% - believe that they are created directly at classes (figure 1).

![Pie chart showing factors influencing strong team creation](image)

**Figure 1.** What do you think can influence building a strong team?

After conducting laboratory classes and course design in teams, more than 60% of students answered that their group is a team (figure 2) and more than 70% - that they themselves are good "team players" (figure 3).
Figure 2. How do you rate your fellow students for teamwork?

Figure 3. How do you rate yourself for teamwork?

When working in a team, students value most of all the teammate’s reliability, while the teammate’s knowledge and experience are not so important to them (figure 4-5).

Figure 4. “When working in a team, I value others more”.
Figure 5. “When working in a team, it demotivates me the most”.

About 70% of students believe that the best professor is the one who motivates students study his subject so that students are happy to deepen their knowledge of this subject (figure 6-7).

Figure 6. “In my opinion, the best teacher is the one who:”

Figure 7. “I learn best if the lecturer”.

The survey shows the educators whose teaching experience ranges from 4 to 41 years (Diagram 8). Most of the respondents are associate professors (63%) and professors (almost 27%). 80% of respondents teach engineering and technical disciplines, 16.7% social and humanitarian and just over 3% - natural science educators.
None of the respondents questioned the need to develop the teamwork skills of students. Absolutely everyone answered: “Yes”.

53% of respondents (educators) called these skills “really important”, almost 27% “vitally important” and only 20% answered “rather important than not” (figure 9).

All of the respondents use small groups, according to the data obtained. It is worth to mention that educators use teamwork organizing students’ laboratory work (80%), as for project tasks (46.7%), problem situations and cases (40%), business games (23.3%), as well as games quizzes, competitions to revise the studied material, joint discussions (nearly 13% in total).

It is noteworthy that when answering the question: "What teams are the most successful in completing an assignment?”, 70% of educators noted that the most successful teams are when all team members actively participate in discussion and listen to each other’s opinions. 30% said that these are teams with a strong leader. And no one noted the team containing an academically excellent student being the most successful one. Only 33.3% of the respondents choose the most successful groups for further extracurricular projects implementation. However, we think it would be a very good idea to involve such groups into research community or cultural projects. And the last question was "Would you like to improve your own communication skills and work in interdisciplinary teams?”. 90% of educators answered "yes, we do”. This allows us to draw an undeniable conclusion of the need to
introduce communication and teamwork skills methods development into the educational process of engineers’ training. It is also possible to conduct trainings for educators to improve these skills too.

6. Conclusion
A synergistic approach for the analysis of teamwork in a multidisciplinary team is presented.

The ways of implementing effective team building in the conditions of training in a technical university are presented.

Our survey of students majoring in "Chemical technology" showed that: 75% of students believe that the creation of a strong team is influenced by the conditions created in the university (platforms, incentives, classes), of which more than 47% - directly in the classroom:

- After the work in laboratory classes and course design implementation, both organized in small groups:
  - more than 60% of students evaluate their academic group as a team;
  - more than 70% consider themselves to be good “team players”;
  - more than 50% - consider that strong team must contain reliable and trustworthy team members.
- Students majoring in "Chemical technology" were tested according to B. Bass's personality orientation diagnostics method. According to the obtained results, more than 70% of students are interested in solving business problems, in high-quality performance of work, focused on business cooperation, and are also able to defend their own opinion in the interests of the business, which is useful for achieving a common goal. All respondents use a group type of activity in the learning process - laboratory work (80%).
- All respondents use a group type of activity during the educational process (80% of which is laboratory classes)
- 70% of educators noted that the most successful teams are when all team members actively participate in discussion and listen to each other’s opinions. 30% said that these are teams with a strong leader. And no one noted the team containing an academically excellent student being the most successful one.
- This allows to draw the conclusions about the need to introduce methods of developing communication and teamwork skills into the educational process of training engineers. It is possible to conduct trainings for professors to improve these skills.

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