Training of engineers in demand in the engineering industry at PSEDA

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Abstract. The article identified the criteria and levels of formation of the supra-professional competencies (team competency) which are essential for future engineers of technical universities, according to the stakeholders' feedback on the priority social and economic development areas. The authors defined the formation levels of team competency among students of technical areas of training at the Research Tomsk Polytechnic University. They described and investigated theoretical and empirical research methods that allowed formulating specific pedagogical recommendations to solve the problem identified in the article.

1. Introduction
Today the engineering activity has an increasingly innovative character and focuses on developing and creating new equipment and technologies brought to the type of marketable products that provide a new social and economic effect, and therefore demanded and competitive. To develop the economy, Russian Federation creates territories with a special legal status relative to the rest of the country and favorable economic conditions for entrepreneurs.

Resident enterprises have modern knowledge-intensive production, which entails a complication of professional activities and requires from educational institutions fundamentally new approaches to training engineers. Today, competitive production needs engineering personnel with a new consciousness, with the necessary competencies and capable of giving a positive impetus to the development of the industry. The very innovative development of an enterprise predetermines its ability to create new competencies. Nowadays a technical university graduate should be able to plan, design, produce and apply complex engineering objects, processes and systems with added value in modern teamwork conditions.

To improve the quality of engineering education, Russian institutions of higher education are moving to federal state educational standards FSES 3++, focused on quality training of graduates to perform labor functions through active interaction between higher education and labor. The universities are modernizing the main professional educational programs according to the new standards.

Team competency according to FSES 3++ is included in the list of general cultural competencies of a graduate. A modern university graduate besides having professional knowledge should have teamwork skills and the ability to realize himself in various social roles.

2 Subject and Methods of Research
2.1 Analysis of psychological and pedagogical literature
Our analysis of psychological and pedagogical literature, both in Russia and abroad, shows that there are scientific and educational prerequisites to solve the problem of forming a team competency that meets the modern requirements of engineering activity. The most important works that reflect the issues of forming the competencies of team interaction include the works of such authors as E.V. Bolgarina [1], Yu.V. Vasilyeva [2], K. Cruz, J. Pinto [3] et al. The works that describe different pedagogical technologies of forming this competency among students include the work of V.S. Okuneva [4], A.D. Nikolaeva, A.D. Malysheva [5], L.M. Harding [6], Zi-Yu Liu, Zaffar Ahmed Shaikh, Farida Gazizova [7], Nor Kamaliana
Khamis, Amirul Mukhlish Abdul Azam. [8] et al. To create a more complete picture of forming teamwork competencies, we used information provided by scientists who study the value systems of different social groups: C.S.Burke, S.M.Fiore, E.Salas [9] et al.

However, despite the valuable contribution of available research, we should note that the professional pedagogy does not yet pay due attention to the problem of forming team competency in the training of such an economically important specialty as a mining engineer, and there is no correlation with the peculiarities of their training.

From the analysis of various scientific works, we will understand team competency as the ability to work effectively on a designated problem in various project teams. It includes the ability to intelligently build communication within a team, the ability to take responsibility for personal and team results, and to participate in resolving intra-group conflicts.

The article aims to reveal the formation level of team competency of future engineers in the transition to FSES 3++ and to substantiate the effectiveness of implementing the collaborative approach to form team competency in the educational process of the university.

2.2 Research Methodology
We tested the CDIO Syllabus training results assessment model on specialists of industrial enterprises. The study involved 146 managers at various levels.

The method of collecting information is a formalized interview. We used a 5-point scale to assess the required competencies and, consequently, the results of training future specialists. The table shows the assessment based on the average value of received employers’ answers.

We monitored the development of team competency among students through observation of students' ability to work in a team, questionnaires and interviews. The research involved 135 students of 3–4 years of technical training from the National Research Tomsk Polytechnic University.

The monitoring was conducted in the first semester of 2019/2020 academic year.

3 Survey Results Analysis
3.1 Formation levels team competency
In our research we monitored the formation of team competency among engineering students at the National Research Tomsk Polytechnic University. To study the development of team competency, we identified assessment criteria and levels of its formation considering the standards and analysis of various researchers' work (Table 2).

| Criteria | Formation levels |
|----------|------------------|
|          | Low | Average | High level |
|          |     |         |            |
| Communica
tion skills | A student cannot build effective communication with team members. A student does not know how to listen, clearly express their thoughts. | A student attempts to build an effective system of communication with team members, and not always can clearly articulate his proposals, ideas and present them. | A student clearly and precisely expresses his thoughts, ideas, is able to listen attentively, convincingly gives arguments, can defend his point of view. |
| Teamwork activity | Personal interests always dominate the interests of the team. A student refuses to perform the tasks assigned to him, cannot negotiate. A specialist generates a conflict situation within a team. | Personal interests tend to dominate the team ones. A specialist performs the assigned tasks only with urgent requests. Loner. A student is reluctant to perform his part of the work, not interested in the overall team result. | The interests of the team are above their own interest. A student shows initiative, puts forward ideas and is ready to help. A student fully fulfills the tasks assigned to him. |
| Responsibil
ty for the team's results | A student makes mistakes and inaccuracies while performing the tasks. A student does not fit within | A student periodically allows inaccuracies in its activities, thus limiting the effectiveness of the team. | A student fulfills his tasks exactly in time. |

Table 1. Formation levels of team competency
Based on the selected criteria, the authors studied to identify the level of formation of team competency among students of RTPU. Totally 135 students took part in the research. The results are shown in Figure 1.

The results of the study show that the majority of students have mainly the average level of formation of team competency. In other words, the model of education even in competitive universities such as RTPU has difficulties in forming competencies according to the requirements of FSES 3++. In this regard, we can conclude that this problem can be overcome by using a collaborative approach to learning.

### 3.2 Collaborative approach to learning

Collaborative learning integrates knowledge and creates "natural learning" situations (as an opposition to a trained result from a highly structured learning situation). Working in a team, students achieve high results due to the synergy effect, i.e. when they achieve together a result that cannot be achieved alone.

Interest in the collaborative approach is growing both in Russia and abroad, as evidenced by several publications [10,11,12,13]. However, the authors' analysis shows that there is a shortage of designed methods for developing teamwork skills, including training in mining specialties.

The process of forming team competency of future engineers should include the following stages:

1. **Creation of professional significance and personal value of teamwork among students.**

   After leaving the university, the future engineer usually still needs a lot of time to adapt to the professional environment.

   The professional value orientation of the graduate ensures his conscientious attitude to the chosen profession, causes the desire and striving to engage in professional activities as soon as possible. It becomes possible if the educational process is close to real professional activity. Consequently, all tasks performed by students in special subjects should be related to specific production problems or have an applied nature.

   In real life, a mining engineer has to face all kinds of challenges, including extreme ones. Some tasks can be easily solved according to the previously studied algorithm, but there may arise tasks that require analysis, synthesis and so on, that is the problem of operational solution at the level of a large team. In most cases, when students have a choice between group work and individual work, they usually choose individual work because they consider they can do the work much faster and better than in the group. However, some goals cannot all be achieved individually.

   It all depends on the specific task and the level of responsibility for the result. Students should clearly see the synergy effect of working together on a simple example. It is possible to offer students a task with the choice of a joint activity or an individual task with the definition of time parameters for the task. The result will be obvious. Students that team up and distribute tasks among the team members will cope with
this task faster and with the least effort. It is necessary to discuss the results with students. The role of the teacher is to show all the advantages of teamwork on a concrete example. It is to help the student realize that his future professional activity, his professional growth is constant collaboration, interaction with the team.

While working in a team on practice-oriented tasks and issues, considering the specifics of the professional activity, in the future the adaptation period will pass faster, they will form a value attitude to the future professional activity, which ensures their competitiveness and mobility in the labor market.

2. Consideration of individual personal qualities and value orientations of each team member when organizing teamwork.

Students experience strong emotional experiences during teamwork. They arise at the moment of task distribution, in the process of selecting various alternatives to solve the problem, in preparation for project protection. All members are responsible for the result of teamwork, and confidence in future success unites the participants. In the course of their work, students have to face the individual uniqueness of each group member, show respect and tolerance for each other, and provide support. One condition for the achievement of the set tasks is the presence of psychological and emotional comfort in the team.

An engineer sometimes has to work overtime. The reason may be narrow terms of project delivery or an unforeseen situation that needs to be quickly eliminated. It is unacceptable to have non-constructive interpersonal conflicts for efficient, fast, well-coordinated teamwork. Thus, to organize effective and well-coordinated work, all team members should have a common point of view in understanding the norms of social behavior, morality, acceptability of certain methods, i.e. have common values.

Students work as a team on a project and interact with each other not only on a learning issue but also on a number of other issues. Therefore, the existence of common value orientations is very important in achieving an educational goal. Diagnostics of value orientations allows the teacher to correctly realize what roles students are capable of playing in a team, who will succeed in the role of leader, and who is an effective performer.

In addition, teamwork effectively influences the formation of value orientations. The influence of group values leads to the generalization of individual orientations. Teamwork results in the formation of a positive value attitude among individual students towards their future professional activities.

A group without cohesion, unity of opinion, mutual trust, mutual assistance cannot be called a team. Teamwork is built according to the following principles: effective interpersonal communication; the ability to work in harmony; group relations are open, and the group is ready to face any difficulties and obstacles in the way of effective work. This results from common value concepts.

Thus, when forming teams to maximize the effectiveness and coherence of their work, the teacher should consider the value orientations of students and their personal characteristics [15].

3. Role of a teacher as an organizer who guides students to make decisions by realizing the potential of the group as a whole and each of its participants individually.

When organizing teamwork, the role of the instructor is more of a mentor. His task is to support and guide the team to achieve the planned result. In addition, the role of the teacher involves the ability to choose technological, organizational, socio-psychological capabilities to achieve maximum pedagogical results. The organization of student teamwork allows teachers to get to know students better and maintain effective independent, group work of students [14].

The teacher's intervention should be kept to a minimum. The initial stages of teamwork may require more support from the teacher, but in the future, he should become an observer from a team organizer and guide the team toward the goal only if it is necessary. Once the team has achieved its goals, the teacher should encourage students to reflect on the process and the results of the teamwork. This will help to determine the mistakes and obstacles that prevented the achievement of the set goal. The result of teamwork largely depends on properly built in communication between team members. There are several rules for students to know:

- listen carefully to the team member until the end;
- start speaking only after the previous team member has finished speaking;
- ask questions if everyone understood what you wanted to say;
- make suggestions and ask others to Express their opinion and add;
- openly express their opinion and be interested in the opinion of others;
- discuss proposals and ideas collectively;
- come to a common opinion together;
- sum up the results together.
Teamwork is a very effective way to learn how to solve problems. The process of problem solving forms such important personal qualities of the future specialist as a creative, non-standard approach to solving professional problems, creativity, independence, ability and willingness to self-development, self-actualization, ability to set goals independently, to put forward ideas, ability to plan their activities and analyze their results [16,17].

4. Conclusion
Our research resulted in the following conclusions: it is possible to solve the mentioned problem and to form a high level of team competency of future specialists when implementing a collaborative approach to education in the educational process of the university. Firstly, the relevance of the collaborative approach is that it orients future engineers to work in an innovative mode, motivating them to find a non-standard solution. Secondly, teamwork develops the ability to listen and understand others, to express a point of view, to find a compromise, which meets the requirements of the new federal state educational standards and makes the future engineer quite competitive specialist in the labor market, demanded in priority development areas.

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