Abstract. The paper discussed the effective team-building technologies in engineering education. The relevance of the research is due to academic and industry based research the emphasized the need for competitive engineers who possess professional competencies and personal qualities as well as engineering graduates who need to work on solving complex problems in teams composed of professionals from many disciplines. The paper describes supported by examples how teamwork can be integrated into the curriculum in conjunction with engineering projects and topics. The research emphasize that students need to understand principles and attributes of effective teamwork, practice teamwork, receive feedback on teamwork, and adopt practices of self-monitoring and self-regulation in their teams. The study offers a methodological training system that includes active teaching methods and a more pragmatic approach in teaching students the skills necessary to function as effective and productive team members. Teamwork skills are increasingly being sought when hiring engineering graduates and employers assume they raise the status of an organization in the market and increase its profit by improving the quality of solving interdisciplinary tasks with minimal time costs and maximum productivity. It also motivates employees and facilitates bonding within the company, opportunity to work together in close proximity leads to strong relationships.

Keywords: Team building technologies · Collaborative learning · Engineering university

1 Introduction

1.1 The Urgency of the Research

During last decade academic and industry based research has emphasized the need for competitive engineers who possess both professional competencies and personal qualities as well as engineering graduates who need to work on solving complex problems in teams composed of professionals from many disciplines and exhibit high level of communication skills. Ability to function effectively within a team is one of the important graduate attributes for engineers [1]. At the moment, various projects and design technologies are being actively introduced in production. Therefore, professionals able to work efficiently as part of different creative teams are becoming more popular. Team members need to coordinate steps and actions in joint activities, maintain a high pace of work, understand and solve their individual tasks to achieve a
common goal and potential. The solution of the stated issues on the training of such personnel is linked with the active introduction of team building technologies, flexible methods and teamwork skills into the process of training students.

Nowadays ability to think creatively and work in a team becomes one of the most important skills. We need to find a new methodological training system that includes active teaching methods and a more pragmatic approach in teaching students, the skills necessary to function as effective and productive team members. Teamwork skills are increasingly being sought when hiring engineering graduates and as employers assume they raise the status of an organization in the market and increase its profit by improving the quality of solving interdisciplinary tasks with minimal time costs and maximum productivity. Researchers also talk about their motivational capacity in engineering education [15, 7], team building facilitates bonding within the company and gives an opportunity to work together in close proximity that leads to strong relationships [2, 6].

Initially, an academic group is not a team, as it is organized spontaneously from people with different levels of knowledge, life experience and ambiguous attitude to team work. But in the learning process, students interact with each other, acquire new knowledge and skills, solve the tasks assigned to them, gain teamwork skills, and gradually, a student group becomes a team. It is possible to organize students’ team work if team technologies are not applied fragmentarily in a separate discipline, but during the entire educational program, then students would gain the experience of team interaction. “Weaker” students can get more benefits of working in a team when they work with “stronger” students.

As a rule, a student group consists of a constant number of people, and it is impossible to find candidates for certain team roles, taking into account the level of training, personal qualities and psychological characteristics. Therefore, student teams are aimed at reducing and overcoming interpersonal conflicts and the level of hostility, understanding each other, team building contributes to the positive emotional interaction of its members, encourages creativity, self-management and self-development when performing joint tasks. All above mentioned purposes of team building define the relevance of our research.

Compared with an ordinary group of people, a team has a number of advantages:

- a team consists of like-minded people which is better and more effective than working individually;
- the possibility of team members displaying their talents and skills is higher;
- flexibility and mobility of team members, their ability to quickly adapt to new working conditions;
- versatility of team members, which makes it possible to solve a wide range of work tasks and problems;
- cohesion within the team, creativity and collaboration.

During the university period, a team which was spontaneously formed from students with different backgrounds from the first-year to senior year goes through all the stages of team development including team formation, its functioning and breakdown after graduation. The authors of this study conducted observation for three years. Two groups of bachelor students learned English on their 3rd and 4th year.
1.2 Literature Review

Team building and teamwork skills have been studied by different sciences such as management, economics, psychology, sociology, pedagogy, and others. Most researchers consider a good team as an innovative resource for company development with a shared leadership roles and specific team purpose, and effective team building is in active problem-solving meetings with open-ended discussions and performing collective work products when real work is done together [8, 12]. Smith [11] states that effective teams have positive interdependence, individual and group accountability, they promote interaction, teamwork skills, and group processing.

Cooperative or Team-based Learning was used in Germany, the Netherlands, the UK, Australia, Israel, and Japan. But basically, team-based learning technology was developed by three groups of American educators from Johns Hopkins University (R. Slavin), University of Minnesota (Rogers Johnson and David Johnson), and a group from California (J. Aronson). The ideas of teaching in cooperation throughout this time have been developed by the efforts of many educators in many countries of the world. Johnson and Johnson [5] point that to be cooperative and reach the full potential of the group five essential elements need to be carefully structured into the situation: positive interdependence, individual and group accountability, promotive interaction, appropriate use of social skills, and group processing [4, 12].

Scientific literature analysis on team building technologies and team development shows in most cases the attention of scientists is paid to successful business team organization and the interaction of employees in the business community [3]. Therefore, it is necessary to adapt well-known business technologies to the educational process. Teamwork fits into the paradigm of “student-centered” training, which is quite relevant today, as opposed to the adaptive-disciplinary model, where the teacher has a leading role [14]. Interaction involves formal equality in discussing problems between the teacher and students.

In our article, we will analyze the most successful techniques and examples of team training, in particular, the features of training in the cooperation of foreign language students in a non-linguistic university.

2 Research Methodology and Materials

Team-building is based on student-centered approach, which is widely used nowadays compared to the teacher-centered model, where the teacher has a leading role. Interaction means formal equality in problem discussion between the teacher and students (it is clear that the teacher should emphasize this equality, while managing discussion). Second of all, teamwork lays on project-based learning, which is used in various ways in different universities around the world.

Research participants are Master students (total number 100 people) majoring in Technosphere Security. We observed them in Bachelor Studies and found that 50% of students in the third year had a low level of readiness for teamwork and experienced the fear of teamwork due to difficulties in establishing contacts with their classmates and lack of flexibility in communication. 29% of respondents have an average level of
readiness for team work, this indicates the possibility of students conducting team activities only under the supervision of a teacher, who designates rules for each student and controls them. Such a team can work effectively only under certain circumstances. 21% of respondents showed a high level of team work. These students know how to interact and can easily use teamwork skills in their studies. Active training methods are used to develop team-building skills.

We use a set of systemic, competency-based, learner-centered, interactive and axiological approaches to ensure effective collaboration and teamwork skills which are based on creativity, dialogue, trust and personal responsibility in achieving a common goal. Teachers use blended learning (flipped classroom) and different activities such as lectures, results analysis, discussion, and practical work. For example, 20 min for lecture on the topic “The History of Chemical Science”, followed by a questionnaire on a well-known scientist-chemist, where students try to guess different scientists using questions. The key condition is to choose a learning material with an appropriate level of difficulty, clear explanation of tasks (no more than 10 min), results analysis and lecture discussion (10–15 min), finished with lecture. Such a lecture can be followed with practical work on a lecture subject for 15 min. The big problem is student’s ability to do tasks independently. Moreover, most students face big challenges with search engines when they need to find answers to the questions as they don’t know how to form questions correctly. At the beginning of the training, we have a workshop on teamwork technologies. Our aim is to give information on team building technologies: planning, estimating, tracking progress, managing changes and risks, communicating complex ideas clearly, and participating effectively as team members. Workshop goal is to inform students on the stages of team building: acquaintance, general vision, positioning, planning, and action.

It is necessary to make changes to the educational process in order to enhance student’s motivation to acquire the skills of independent cognitive activity, i.e. to form the ability to think creatively. While studying “Types of Technosphere Safety”, students are organized in groups of four to six people and every group works with educational material divided into fragments that are logical or semantic blocks. To get the full picture students search for missing pieces of information so that this technology involves teamwork. This type of team activity is effective when students work with special texts, reading and discussing professionally oriented vocabulary.

Master’s degree students were ready to work as a team when they had a class called “Managing Learning Processes”. They can independently assign roles and are responsible for assigned task. For example, a group of students chooses the topic “Reducing noise in compressors”. They study causes of noise and develop different ways to reduce noise while compressors operate, and suggest special noise-insulating materials. They propose to replace a compressor running on rolling bearings with magnetic bearings and emphasize on a number of advantages such as low noise, since metal-metal friction does not occur; increase in efficiency due to increase in rotor speed. When replaced with magnetic bearings, the noise level is reduced to 40%, which economically efficient. Doing these tasks, students develop the following teamwork skills as empathy, dialogic communication, and productive feedback.
3 Discussion

3.1 Team-Based Technology in Foreign Language Teaching

Team-based teaching, as a component of the Communicative Language Teaching is becoming increasingly popular in teaching foreign languages in higher education. According to the researchers, this technology puts the student at the center of the educational process and organizes its interaction with other students [9, 10]. This technology of teaching a foreign language contributes to the creation and development of an innovative educational environment in a non-linguistic university. A language teaching is organized according to the principle of teamwork. The group of students is divided into teams of 4–5 students. The teacher gives each team the task of developing different topics. Students distribute the roles and contributions that everyone makes; they also plan the volume and progress of its implementation, structure of presentation upon completion of the work.

Teaching English at an engineering university is focused on studying vocabulary and terminology, reading specialized technical literature, and communicating in the field of professional activity. Students need to develop communication skills to be able to communicate in English on professional level. They need to master formal and informal language, participate in group discussions and learn to share their opinion on variety of engineering topics.

Student Team Learning is one of the examples of successful implementation of team-based learning. The main idea of this model is to create conditions for group activities of students. According to researchers, the training method in a team comes down to three basic principles: “rewards” (team rewards), when a team receives one “reward” for all in the form of an assessment of joint activity; individual accountability, where the success of the entire group depends on the successes or failures of each of its members, which encourages all team members to monitor each other’s successes; equal opportunities for success, while each student brings points to his group, earning them by improving their own previous results [13]. The main advantage of teamwork is in active participation of students and the emergence of communication opportunities. The effectiveness of this method depends on the implementation of several aspects: training students to work in groups, the constant inclusion of this activity in the educational process, the distribution of roles (timekeeper, press secretary, researcher, scientist), monitoring the joint implementation of tasks. A group discussion of a number of questions on a specific topic (for example, “The History of the Development of Chemical Science”), exchange of opinions, the ability to ask questions and agreement/disagreement, the ability to listen and understand are examples of successful teamwork.

Jigsaw method is another option for organizing educational activities in small groups, when students organize in teams of four to six people and work on learning material, which is divided into fragments – logical or semantic blocks. This technology involves the collective work of students in the search for missing pieces of information to get the full picture. This type of training in collaboration is effective when working with special texts, reading and discussing professionally oriented material. The jigsaw method covers all four types of speech activity, allowing students to process
information in a “comfortable” environment. For example, a student is issued a card indicating the name of a well-known chemist, the task of the rest, using questions, is to guess the alleged person. The key condition is the choice of material with the appropriate level of complexity; clear statement of tasks.

Role-play is also an effective method of team-building activity. In role-playing, a group is usually divided into small groups, often couples, various conditions are modeled, situations as close as possible to real ones, and roles are distributed. Role-playing game gives many different opportunities to develop communication and negotiation skills, stimulates creative thinking, and involves problems solving. Studying the topic “Safety Rules in Chemical Laboratories”, students model a business game by simulating a laboratory class, distributing roles, offering visual material, studying the necessary vocabulary, and reaching the ultimate goal - instructing correct and incorrect behavior in chemical laboratories.

The Learning Together method involves dividing the group into three to four people, who can be both homogeneous in terms of foreign language proficiency or combining weaker and stronger students. This approach has a number of advantages, including mutual learning, providing the opportunity for joint discussion, separation and comparison of acceptable answers to questions or situations, using the target language, working in pairs of strong and weak students. The Learning Together technology can be successfully applied when studying the topic “Types of Engineering”, while the task of each group is to prepare information on the types, achievements, pluses and minuses of engineering activities. There are various options for using this method during classes:

- peer review, when partners exchange projects or written works and analyze each other;
- artificial debates, structured public discussions that allow students to show their point of view and convince a third party of their innocence (when discussing the advantages and disadvantages of engineering);
- dialogues that are aimed at repeating and consolidating authentic phrases and expressions in accordance with the context.

3.2 Cinquain Technique in Team-Building

Cinquain is a five-line poetic form that appeared in the USA at the beginning of the 20th century under the influence of Japanese poetry. In the future, it began to be used for educational purposes as an effective method for the development of figurative speech. Cinquains are useful as a tool for synthesizing complex information, as a slice of the assessment of students’ conceptual and vocabulary. First of all, educator’s task is to explain to students that cinquains fit knowledge, thoughts, feelings, emotions, and associations in a short form. These five-line stanzas are able to express opinions on any issue, subject, event, or phenomenon. Educator explains the basic rules for writing five-line stanzas providing a few examples. In this genre, verse has both a strict meter and rhyme scheme. Cinquain is usually unrhymed and defined by the number of syllables in each line—the first line has two syllables, the second has four, the third six, the fourth eight, and the fifth two. The text itself is based on the meaningful and syntactic
meaning of each line rather than on syllabic dependence. The first line embraces the theme of the cinquain, which contains one word (usually a noun or pronoun), which designates the object or subject that will be discussed. The second line – two words (most often adjectives or participles), give a description of the signs and properties of the object or object selected in the cinquain. The third line is formed by three verbs or participles that describe the characteristic actions of the object. The fourth line is a four-word phrase expressing the personal attitude of the cinquain author to the described subject or object. The fifth line is one word describing the essence of an object or object. Strict observance of the rules for writing cinquain is optional.

Cinquain writing is a form of free creativity, requiring the author to be able to find the most essential elements in material, draw conclusions and formulate them briefly. It is recommended to use cinquain as a final task on the material covered. Work can be organized both individually and in pairs. Such topics as “Environmental Protection”, “The Earth”, “Enormous, generous”, “Live, produce, pollute”, “We must protect”, “Our planet can be organized using cinquain technique.

3.3 Developing Teamwork Skills Based on Urgent Engineering Topics

A round table “Advances in technology” consists of several steps. First step begins 1–2 weeks before the round table with the problem and the purpose of the discussion formulation. Students receive the task: to collect information from various sources about the problems, dangers, threats and benefits that accompany the rapid development of technology in the modern world. A problem is diagnosed and discussed during the class using a brainstorming session. Students are looking for an answer to the question: Have advances in technology caused problems in society? We received the following answers from students pointing at them main problems caused by technology and engineering as ecology, dependence on computer and phone, obesity, problems with transport. Then students make and deliver presentations on the problem with necessary attributes of presentation such as its content, relevance, illustrations, and logically connection. In order to deliver presentations effectively students are recommended to watch videos that help them to greet properly round table participants, present themselves and their report, express their point of view, support the conversation, fill in pauses, put forward arguments and counterarguments, answer questions and end a presentation. Second step is a round table session itself where students give presentations with research results and discuss them in groups. The participants in the round table sit in a circle, facing each other, so that they can clearly see and hear each other, as well as freely use non-verbal means of communication. It is important to maintain a high level of activity for all students, comply with the regulations, and create a friendly and motivating atmosphere. Students listen to and learn about presented topics, discuss them with others, share their thoughts and ideas about each problem. The effectiveness of the discussion depends on students’ preparation, awareness and competence on the proposed problem.

At the final, students filled in a questionnaire about their experience. The survey data indicate that active learning techniques as round tables help students better understand the educational material (65% of respondents were positive); have more
opportunities for individual work with an educator (82%); get more opportunities to master independent work skills (74%).

4 Results

Team building skills are developed among engineering university students majoring in “Technosphere Security” and its methodology is based on cognitive, process-reflexive components. We developed and improved specific teamwork skills involving bachelor’s degree students while teaching English as foreign language and master’s degree students while teaching a class “Managing learning process” based on various educational methods such as (diagnostics, discussion, case methods, group project), techniques (productive feedback, empathic, reflective), tools (cases, professional tasks, diagnostic techniques, projects) and forms (group discussion, practical exercises, project defense). Students were able to self-assess themselves as team members, self-determine their choice of team roles and ways of organizing a team, build interpersonal relationships and solve joint professional tasks. We based on A.A. Kyveryalga methodology to group the indicators while determining team building skills acquisition of engineering university students. The significance of this methodology for our study is that it allows not only to evaluate, but also to control the change in the level of each student, to analyze the dynamics according to certain criteria for each individual respondent and the group of respondents as a whole. At the end of the experiment, 29.31% of students remained at a low level for team work, 31.76% were on average and 38.93% at a high level. As a result of successive stages of training on the example of different classes and years, students could improve their team building skills.

After analyzing students’ profiles we obtained the following results: students consider working in groups interesting (83%), productive (67%), nothing changed (50%). The advantages of group work they see in being more productive (33%), working more actively (50%) and talking more (83%) compared to front work. As disadvantages of group work they pointed: none (50%) and hard work (50%). Students got more interested and involved (100%), gained more confidence (83%) and became passionate about engineering and technology (67%). Percentage of students who prefer more team-based activities instead of other activities on regular basis (67%), once a month (17%) and sometimes (17%). Team-based activities motivate (83%), cause interest (83%) and cause fatigue (17%) to students.

We conducted a written survey according to the method of T. Ilnaya, which showed the following results of students’ motivation: 85% of the students asked showed an increased level, 10% showed an average level of motivation, 5% showed a reduced level of motivation. Students have a desire to acquire knowledge for self-development, which is an indisputable plus for further education. Based on the survey results we determined that the motives of curiosity and the motives for acquiring professional knowledge are ones. The motivation for obtaining professional skills and competencies is the highest, which indicates the awareness of the taken major.
5 Conclusion

Specifically organized learning process that develops and improves team building skills of the university students allowed us to use a methodology aimed at educational tools and techniques for students to study their personal qualities, team roles and interpersonal relationships in a group. The results of the experiment, which was held at our university with the same groups of students (100 people in total), proved that the work was successful. The data obtained indicate an increase team building skills of students. This study does not cover all aspects of the this problem. Further work may be devoted to the development of an online resource for university teachers that help to organize students team work virtually, which is very important during the coronavirus epidemic.

We can name certain advantages of team-based learning: a greater number of students can simultaneously speak a foreign language, which contributes to the development of a foreign language communicative ability; successful students can help underperforming students, so that a relationship of mutual assistance and mutual responsibility is formed; increased sense of responsibility; the psychological climate improves; students are motivated by the opportunity to present the results of team work to other groups; educational and cognitive motivation increases; anxiety level decreases; equally distributed work in a group, there is an opportunity to share ideas and thoughts.

Work in a team makes students more responsive to the task, because the result of their work depends on the overall result of the group. Weaker students get the opportunity to learn from stronger ones or perform more complex tasks that raises their self-esteem and allows them to believe in themselves. In addition, students develop social skills, their ability to work in a team, and this is important for further professional life. Teacher’s function here is observation since it is a student-centered approach students themselves are forced to show activity.

This study does not cover all aspects of the identified problem. Further work may be devoted to the development of an electronic educational resource for university teachers in the diagnosis and organization of student teamwork, which is very important during the coronavirus epidemic.

References

1. Al-Atabi, M., Shamel, M., Taha, O., Chung, E.: Corporate style team-building activities for undergraduate engineering programmes (2010)
2. Barabanova, S.V., Nikonova, N.V., Pavlova, I.V., Shagieva, R.V., Suntsova, M.S.: Using active learning methods within the andragogical paradigm. In: Advances in Intelligent Systems and Computing. AISC, vol. 1134, p. 566–577 (2020)
3. Burylina, G., Sanger, P.A., Ziyatdinova, J., Sultanova, D.: Approaches to entrepreneurship and leadership development at an engineering university. In: ASEE Annual Conference and Exposition, Conference Proceedings (2016)
4. Johnson, D., Johnson, R.: Making cooperative learning work. Theory Pract. 38, 67–73 (1999)
5. Johnson, D.W., Johnson, F.: Joining Together: Group Theory and Group Skills, 10th edn. Allyn & Bacon, Boston (2009)
6. Katzenbach, J.R., Smith, D.K.: The discipline of teams. In: Harvard Business Review (1993)
7. Kaybiyaynen, D.A. Kaybiyaynen, A.: University as a center of project-based learning of school students. In: Proceedings of International conference on Interactive Collaborative Learning, pp. 1018–1021 (2015)
8. Khatsrinova, O.Y., Tarasova, E.N., Ovsienko, L.V., Yushko, S.V., Galikhanov, M.F.: Engineering education: elite training at a technological university. In: Advances in Intelligent Systems and Computing (2020)
9. Panteleeva, M., Sanger, P.A., Bezrukov, A.: International approaches to the development of cross-cultural education at high school. In: ASEE Annual Conference and Exposition, Conference Proceedings (2016)
10. Shageeva, F.T., Bogoudinova, R.Z., Kraysman, N.V.: Teachers-researchers training at technological university. In: Advances in Intelligent Systems and Computing, vol. 917, pp. 977–980 (2019)
11. Smith, K.A.: Teamwork and Project Management. 3 edn. Basic Engineering Series and Tools. McGraw-Hill (2007)
12. Sultanova, D., Maliashova, A., Bezrukov, A.: Consistent development of the training program “innovation management” (2020). https://doi.org/10.1007/978-3-030-40271-6_24
13. Tsareva, E., Bogoudinova, R., Khafisova, L., Fakhretdinova, G.: Multilingualism as a means of students’ technocommunicational competence forming at engineering university. In: Auer, M., Hortsch, H., Sethakul, P. (eds.) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. Advances in Intelligent Systems and Computing, vol. 1134, pp.137–142. Springer, Cham (2020)
14. Valeeva, R., Ziyatdinova, J., Osipov, P., Oleynikova, O.: Development of international academic mobility: success stories. In: Advances in Intelligent Systems and Computing. AISC, vol. 1135, pp. 443–454 (2020)
15. Yushko, S.V., Galikhanov, M.F., Barabanova, S.V., Kaybiyaynen, A.A., Suntsova, M.S.: International network conference as an efficient way to integrate universities and businesses in the context of digital economy. In: Advances in Intelligent Systems and Computing. AISC, vol. 1134, pp. 663–673 (2020)