


Collaborative Learning in Engineering Education: Reaching New Quality and Outcomes

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Abstract. The article presents the research on the means to enhance collaborative learning practices, to reveal its potential for engineering students' soft skills formation, as well as to trace the connection between purposeful organization of collaborative activity by a teacher and new level of learner's participation in collaborative activity. The recommendations on the choice of the appropriate interaction model for teachers organizing collaborative learning are provided and the principles of open educational teaching activity with the space for sense-making and student initiatives are generated. The research approach based on phenomenological description of the precedent (class organized with the use of case-study method) allows to reveal and analyze the educational potential of the method used and its effect on the quality of collaborative learning.

Keywords: Soft skills · Case-study method · Collaborative learning

1 Introduction

Today an engineer is to work in an extremely heterogeneous and fast changing world, the subjects of which are interdependent. The basic competency of contemporary engineering graduates is to carry out their activity in the area of the latest innovative technologies and developments, with account for global trends, varying social structures and modern people's needs [9]. The given ability is determined not only by mastering *professional competencies* in a broad sense of the term (so-called *hard skills*), but also *universal strategic competencies* (so-called *soft skills*) which can be revealed in professional activity in the area of interpersonal communication. The soft skills include:

1. ability to communicate: to negotiate, discuss, argue, prove, build communication for effective achievement of the set objectives, and solve conflicts;
2. critical and creative thinking;
3. skills of team work when doing an interdisciplinary task;
4. self-learning process management due to individual education-career trajectory (*autonomous learning*) and others.

Soft skills formation and development are pedagogical problems being solved by the active methods of learning organization (case-study method, problem-based learning, project learning, etc.). Referring to active learning methods, the first is related to changes in learning objectives, transition from ready knowledge translation to learning and processing of a completely new, team-generated knowledge. The second one targeted at the building of educational relations between a teacher and students and organization of non-didactic interaction between them (not only teacher teaches a student, but also a student can teach his teacher something) [6]. In our research, we would like to point out the main pedagogical principle of the already existing method - principle of cooperative learning organization for the teacher and the students - and to consider it over, i.e. enhancing its humanities, communicative and interpersonal components. Furthermore, we provide a set of recommendations herein for class organization, which contribute to performing a collaborative learning activity at a new level, facilitating a successful soft skills development for future engineers.

First ideas about changing the learning type for students to get more opportunities, have a dialogue with each other, learn from each other, look for solutions to various problems cooperatively, were expressed in the 1950–60s by teachers of secondary schools and medical institutes of the United Kingdom (Ch. James, L. Smith, M. Abercrombie). Those ideas were supported in working practice by American universities' faculty in the 1970s, as a solution to a big gap in knowledge and academic skills among the students, an attempt to form cooperation and mutual assistance between weak and strong students for gradual "leveling" of an academic group (D. Bremer). Collaborative learning became a part of common educational practice in the 1980s: it has evolved into a methodological principle of learning management rather than a simple technology. This principle does not rely much on the student group work under a studied problem, but focuses on group participation in the process of "intellectual talks", collective decision-making, and the discovering of an opportunity to get control of their knowledge and later to be independent in their application [2]. This principle also changes the view about position and functions of the pedagogue. To organize the conditions updating collaborative learning, teachers should think over their role in the learning process and transform the position of the ready knowledge translator into the organizer, facilitating mini-communities in the classroom that aspire students' self-development and self-learning [1].

Collaborative learning is also applied in engineering education, despite a number of difficulties: difference between the classic engineering education and active educational unreadiness as well as low motivation of some students (especially the strong ones) hinder successful collaboration in the group [8]. Collaborative learning constantly demonstrates the qualitative changes in the results of contemporary engineering education: development of teamwork competency, communication skills, a new level of the subject knowledge (*knowledge obtained through participation as result of action*), acquisition of responsibility for own learning (both individual and shared by team members) [8, 12].

Collaborative learning in Russian pedagogy should be perceived within the Post-Soviet tendency towards democratization and transparency in education. Integration of foreign educational methods and principles with Soviet pedagogical science resulted in several approaches, based on democratization and humanization of

educational process, active learning methods, developments of the Soviet period psychology (Leontyev's activity theory, Elkonin-Davydov theory of learning activity and developmental teaching). One of such approaches we draw upon is pedagogy of collaborative activity, authored by the Russian scholar G. Prozumentova.

Within the framework of collaborative activity pedagogy, the focus of research is directed on collaborative activity as a factor of influence on a person's education, as the subject of special efforts by the teacher who organizes, directs, facilitates, and summarizes students' collaborative activity. Thus, we take a great interest in *organization* of such *collaboration* (beginning, development, ending, teacher's role at every stage of collaboration), its *qualitative assessment* (nature and effectiveness of collaboration, the degree of students' engagement and its effect on a final result), tools of *experience reflection* on taking part in this kind of activity by the students themselves to develop their critical thinking, to form a conscious and responsible position towards one's own education.

2 Materials and Methods

Materials and methods used in our research are presented within the logic of the humanities research approach developed by Prozumentova [11]. The approach is distinguished by participation, involvement, and introduction of the persons into their development and education. The humanities approach distances itself from "external nature" of science as a body of knowledge and makes subjectivity a cornerstone viewed as participation, understanding, interpretation and description. Participation in the collaborative activity is related to acquisition of new experience, requiring understanding, correlation with a person's own values and needs, interpretation, analysis for further studying by the participants (students, teacher). These requirements determine selection of the research method: it is based on the phenomenological approach which is focused on direct study of experience with the emphasis on importance and sense of subjective view of the situation, view of consciousness as a given, active and filled with sense, as well as recognition of new knowledge generation from subjectification of life experience, reflection on personal experience [10, 13]. The act of personal action of self-description, the interpretation, and discovery by the person of the sense of their actions is important for us [7]. The next step is based on textual descriptions of phenomena (teachers describe their own experience in collaborative learning organization) where specification of repeated typical signs of phenomenon are observed, then the phenomena are systemized and systematically interpreted. These procedures bring the stated research method closer to the grounded theory by Strauss and Corbin, based on the unique research movement "vice versa"; from facts description to their explaining, from understanding to the notion, from presentation to justification, from the given to its conceptualization. By explaining the necessity of such research movement "vice versa" (traditionally the research moves from building the concept to analysis of particular cases), Strauss, Corbin note that such research allows investigating "stories of life and behavior...organization activity" and thus create the "grounded theories" [4].

3 Situation. Application of Case-Study Method for Collaborative Learning

The description of case-study method application at the stage of new topic introduction, module “Ecology” is presented. The following case was discussed in class: “Industrial waste is a global problem of our time”, the case author is the 2nd year student.

3.1 Description of the Phenomenon

At the first stage i.e. to involve the learners into communication, they were suggested to participate in the process of cooperative formulation of the coming class topic. To engage the maximum number of participants, the association method was used: students had to choose the associations to the term “*energy sources*”. Different opinions were expressed and various types of energy sources were named (*coal, wind, water, uranium, etc.*), some adjectives (*natural, expensive, dangerous, etc.*), and set expressions (*power plants, generate energy, etc.*) were listed. Thus, we managed to involve *all* participants in the communication. Associations with the suggested expression were so different and unexpected that, for example, some adjectives suggested in the list of associations e.g. “*innovative*”, “*provoked*” a question from other participants about what such association is connected with, followed by the student’s explanation that today innovations in different spheres are actively discussed and in future a new source of energy could be discovered and named innovative. It was not only the number of participants that increased but also directions of interaction, characterized by questions to each other referring to personal experience and interdisciplinary knowledge.

Then participants were suggested sharing information about new, just discovered energy sources that can be considered as innovations nowadays. Communication organization in such a way is characterized by increase of participants’ number, number of questions to each other, multiple and various statements, involvement in the discussion relying on the personal experience, available knowledge, and here the communication is not anonymous but is presented in I-statements, on behalf of a particular person. In addition, one of the features of such communication is multiple and various topics mentioned within one assignment during a relatively small amount of time. The students discussed such topics as various types of energy sources, innovations in the energy sector, environmental problems, connected with operation of this or that energy type.

The second stage of the class became the stage of collaborative activity development. To involve the students in the collaborative activity, prior to beginning of work with the case each group was suggested discussing and making a list of rules everyone should stick to so that discussion didn’t get into arguments among its participants. The discussion was planned and organized by students themselves, they discussed and decided who would write down the coming suggestions, offered the rules, selected the most interesting suggestions from their point of view and approved the final list of rules.

Having obtained the material for work, students themselves planned their work with case materials, showed their initiatives in goal-setting, determined the work sequence with the material, organized discussion, calculated the time, made decision and chose the speaker. Actualization of learning process sense-making for the

participants was observed during collaborative activity and communication: there were the questions to each other about the point and sequence of actions in working with the suggested material, about nature of this or that opinion and its application in this particular case. Thus, we could observe the transition from “forced”, “prescribed” speaking by the communication and collaborative activity conditions to “natural” and “free” communication.

The third and final stage of the class became the stage of reflection results and process of students’ activity. To involve all the students in the feedback and reflection, each of them was suggested characterizing the class by one adjective, for instance, “interesting, boring, informative, etc.” and explaining their opinion if they wish. Then each of them was offered to answer three questions in writing, such as: “*What new did you discover during the class?*”, “*Where and how could you apply the experience from the lesson?*”, “*What do you wish to improve in work in the class using such case-study method in future?*”.

3.2 Analytical Comment

The suggested model of a class using case study is based on the collaborative activity organization developed by G.N. Prozumentova. We point out three main stages:

The first stage: *Immersion in collaborative activity*.

Key objectives: forming motivation for collaborative activity; demonstration of initiatives of discussion participants. The following options for work are possible at this stage:

1. A case can be handed out to students before the class for independent study and preparation of answers. Knowledge of case by students and their interest in case and its problems is monitored at the beginning of the class.
2. The class can start from prepared questions, actualization and systemizing the students’ knowledge on the topic to be discussed, interdisciplinary connections, and in such a way leading students to the case.

The second stage: *Organization (deployment) of collaborative activity on problem solving*.

Key objectives: organization of group and inter-group discussion, results preparation and presentation. The following options for work are possible at this stage:

1. Students are divided into groups for collective discussion, preparation of answers to questions, making decision during the given period of time.
2. If the case is for self-study at home, then the group compares individual answers, adds them and comes to a unified position, which is shown in presentation. Each group chooses a “speaker” who will present the group decision. After a group presents its decision, an intergroup discussion is organized. Teacher organizes and leads the discussion.

The third stage: *Analysis and reflection on collaborative activity experience*.

Key objective: demonstration of educational and learning results.

At this stage the effectiveness of class organization is analyzed, the problems of collaborative activity organization are shown, the objectives for further work are set.

The teacher actions are to finish the discussion, to analyze the case discussion process and all groups work, and sum up.

Situation modeling allowed not only pointing out the stages of activity organization at the class using case-study method, but also determining the conditions, under which the potential of this method is developed. We found out that change in communication (growth in the number of learners involved in communication, diversity and number of topics discussed), change in quality of collaborative activity (participation in organization and planning, setting and achievement of collaborative activity goals) occur when class participants are given the right to choose topics for discussion, method of activity, opportunity for expressing the initiative is provided, and update of personal experience takes place. Particular emphasis is placed on the role of the teacher, who not only organizes the interaction but also takes an active part in it, proposes new ideas as well as encourages students' initiatives. Moreover, teachers should be highly-qualified, because they need to use a special format at each stage of their foreign language course: from the introduction of the new material to skills development [3].

3.3 Analytical Conclusion

Thus, among educational effects stipulated by the case-study method application, were revealed the effects, serving as evidence of changes in communication and collaborative activity quality, such as:

- *Emergence of personal initiatives and desire to realize them in teamwork and communication.* This is reflected in the way the students plan, arrange their teamwork and negotiate, which is evident from the texts: "I suggest that we first discuss ...", "First, let everyone read, get acquainted with the information, and then we'll listen to everyone' opinion...", etc. During a regular class, the students' speech activity is usually confined to an answer to the question asked by the teacher, and making an exercise, following the model. Thus, students are deprived of opportunity to take the initiative, creativity as well as to be self-reliant in fulfilling the assignment.
- *Personal and emotional engagement in teamwork and communication.* It means that students are not only "involved" in the communication, they "get carried away" and "live" it. Furthermore, in the process of interaction the moments of emotional tension, excitement of students are constantly observed, that is due to existence of problem situation, which needs to be solved, number of students in the discussion, level of their engagement in the problem-solving process, their cognitive activity and availability of different points of view. This can be seen from the following texts: Students: "I was concerned by the fact that ...", "Do not get excited, let the others say..."; Teacher: "... the situation was heating up, Anton insisted on his point", etc.

The quality of engagement provided by the case-study method should be mentioned specifically [5]. Besides personal and emotional engagement, we observe subject engagement, which is reflected in students' desire to build communication in a foreign language during the class. In communication process all students were involved in the discussion, even so-called "low-achieving" students,

who preferred to be silent during the regular class. Being “involved” and “carried away” during discussion, students focused their attention more on the content of statement, gradually going to its quality, when number of grammatical mistakes reduced and the words were selected better, according to the context, there appeared idioms, idiomatic expressions and metaphors in speech. As a result, a conscious and therefore qualitative mastering of subject content took place [5].

- *Search for meaning of their actions, statements as well as of other students' actions and statements.* During communication there were multiple moments of “semantic tension”, related to arising questions – students referring to each other: “Why?”, “What for?”, “By what criteria...?”, “On what grounds...?”, etc. Thus, students try to find and understand the sense of their actions and other participants' actions and phrases.
- *Value-conscious attitude to each other and themselves.* Another important indicator of change in the quality of communication is the value-conscious attitude of students to each other which is apparent from students' desire to listen to and consider each person's opinion as well as put themselves in place of the other. This is reflected in the following texts: “Imagine yourself in his place, what would you do in this situation ...”, “...do not interrupt, it is hard for him to speak...”, to hear and understand the other: “If I understand you correctly ...”, “...by this you mean that ...”, etc.

4 Results and Discussion

Thus, our empirical research has shown that application of case-study method results in the following effects:

- communication intensity increases while a solution to a problem is worked out together with students' emotional engagement;
- students as participants of collaborative activity define collaboration and communication as meaningful component of task completion, they are able to reflect upon their participation in communication and interaction;
- students take various roles in communication and change them while communicating;
- students perceive their activity as meaningful one (sense-making process and students' reflection upon it);
- students see the task they work upon as relevant to their future professional activity.

These effects contribute to development of such soft skills as communication, critical thinking, teamwork, and self-learning organization.

Furthermore, the mentioned above effects emerge when a teacher takes the role of collaborative learning organizer and takes the following steps:

1. coming up with the task which leads into collaborative activity, create a situation which provokes interaction and collaboration between students;
2. facilitating discussion process;
3. defining the interaction rules together with students;

4. transferring to the board and sum up the results of student discussion without imposing teacher's 'right opinion';
5. gathering feedback from students on the process of collaborative activity.

With those steps, taken collaborative learning acquires the following features:

- it is saturated with students' meanings of the actions, their aims and objectives of the task to be completed according to their own priorities and interests;
- various students' initiatives emerge aimed at modifying and the process of content of collaborative learning;
- task completion becomes an activity for the whole team in which each student can take his own role.

Those features can be detected through the feedback from students focused upon their experience of participation in collaborative learning. The questions we ask students can be divided into three main groups: *What?* (What happened during the entire work? Who was involved in work? What needs were met?), *So what?* (What did they think or feel? What did they learn from the experience they obtained in the class?), and *What now?* (What do they know now that they didn't know before? What attitudes and feelings do they have about the experience that they did not have before? Are they aware of any other changes that occurred in knowledge, skills, attitudes, or feelings as a direct result of this experience? If so, explain. How do they actually learn what is most important to them? What do they think they will remember or retain in other ways after the experience? What will they probably share with or demonstrate to others in the future? What changes would they suggest for future group experience?).

5 Conclusion

It is noteworthy that collaborative learning contributes to the engineering education development providing students with various opportunities to gain valuable experience of problem solving in collaboration and communication with peers, reflecting upon such experience and relates it to the aims and priorities of future professional activity.

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