

# Teaching Conditions for Forming Team Competence in IT Specialists Training

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## Abstract

Preparing a successful IT specialist who has a number of personal qualities and abilities that will enable him to effectively solve the tasks of his professional practice is the most important task of the university. Universities in Russia plan educational activities taking into account the requirements of the current economic situation, federal educational standards and their own curriculum to optimize the preparation of the future IT specialist and determine the ways and means of forming key competencies at the level of methods and types of educational activities. The structured and systematized project activity of the students acts as a condition for the formation of the future specialist's universal competences. One of the most sought-after universal competencies today is the ability to work in a team in project activities. Integration of the project activity into the educational environment of the university consists in the development and implementation of the student's individual educational route and will allow actualizing the self-improvement and self-development of the student in professional and personal aspects. The project activity of the student must be structured in terms of goals, objectives, implementation stages, the planned result, activities and methods of influence on student's personal qualities and abilities. Criteria for evaluating the efficiency of the project activities are indicators of the degree of formation of universal competence. We report on our implementation of this idea, including details on the composition of the team, the development methodology and end results. Our experience and methodology can help faculty at other institutions implement similar multidisciplinary capstone projects.

**Keywords:** practice-oriented approach, project activity, project method, teamwork, activity approach, universal competences, personal qualities, professional abilities.

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## 1 Introduction

Over the past decades, the Russian education system has been characterized by a change in ideas about the student's personality, which today serves as the subject of the educational process and is endowed with individual personal characteristics that determine its independence, responsibility, self-regulation and self-development. At the same time, the current economic situation creates new demands for specialists, among whom more and more attention is paid to their intellectual, communicative, organizational qualities, reflection and self-actualization, allowing them to successfully achieve their goals in a broad social, economic and cultural context. The ability to obtain and creatively apply knowledge, think independently and extraordinarily, analyze, draw conclusions, correctly plan actions and carry them out effectively, cooperate productively in a team – these are the fundamental components that ensure the competitiveness of future professionals in the labor market. The most optimal way to form the above personal qualities and abilities within a higher education institution is to integrate students' project activities into the educational process [Bar17].

## 2 Task

The main goal of improving the training of an IT specialist at a university is to create a student-centered educational process based on an analysis of all aspects of their professional activity. Its peculiarity lies in the fact that the student not only accumulates knowledge and acquires the necessary skills and abilities, but also harmoniously combines all the components of professional competence, including the ability to work in a team in the implementation of project activities.

Teamwork is an active process of collaborating to achieve common goals. Creating an efficient team involves the allocation of certain social roles, as well as the presence of signs necessary to achieve the overall goals of the group [Men19]. These include: having well-defined and understandable common goals; availability of special knowledge and skills and professional competencies; motivation for joint activities; a developed sense of community; interchangeability of team members; knowledge and experience in the field of team management [Gom19].

The ability to work in a team lies in the possibility of a synergistic effect from combining group solutions. This means achieving a state in which the whole is larger than the sum of its parts. In order for the parts to become a single whole, students must have a certain personality quality, integrative skills to think critically and work in a team, the synthesis of which is an integrative personality characteristic, due to the ability to think critically in the process of solving collective problems, to propose effective ideas and solutions in a team of like-minded people / professionals [Jär10].

## 3 Development Of Methodology

The ability to search, critical analysis and synthesis of information, application of a systematic approach to solving problems, determining the range of tasks within the framework of the goal and choosing the best ways to solve them based on existing legal norms, available resources and restrictions, carrying out social interaction and realizing their role in a team - all these components of professional competence are especially pronounced in such project activities where a temporary team is used in creating an unique product.

In accordance with the global project management standard (Project Management Body of Knowledge PM-BoK), developed by the Project Management Institute, (PMI), in the context of a higher education institution, project activity is a form of training sessions, the main principle of which is organizing students' activities in such a way that their maximum independence is ensured [PMI08]. The project activity itself is a consistent set of educational and cognitive techniques that allow solving a particular problem on their own [Dau15].

The method of projects in modern studying is treated as a pedagogical technology focused not on the integration of factual knowledge, but on their application and acquisition of new [Smi16]. This technology involves the use of methods using research and searching on one hand, and the integration of knowledge and skills from various fields of science, technology and creative areas – on the other [Cas18].

Didactic problems solved with the help of the project method:

- actualization of interdisciplinary relations in the process of preparing students;
- a more complete implementation of the interrelations of theory and practice in the educational activities of students;
- increasing the level of learning theory and practice by students;

- increasing the activity of students as subjects of the educational process, strengthening the role of self-education, self-learning, self-development;
- targeted professional competence and metaprofessional high-quality trainees [Anw18].

The main result of the study is mastering the generalized methods of actions and competencies represented in the GEF.

Competence is formed and manifested only in the process of activity and its quality is determined by the degree of involvement. Consequently, the project activity will allow solving the fundamental tasks of modern higher education:

- targeted organization of learning;
- development of abilities to apply knowledge and skills for solving practice-oriented tasks;
- formation of GEF-issued competencies by the implementation of the activity approach to learning [Pan18].

Formation of team competence in the process of IT-specialists preparation will be more successful if the following pedagogical conditions are met:

- team-based solution of practically-oriented goals is accounted for by the structure, content and technology of the education program;
- application of teamwork technologies is realized with adherence to the requirements of the principles of necessity, sufficiency, additiveness, optimality in regard to other educational technologies;
- formation of teamwork preparation for students of IT specialties is realized as a purposeful process of preparation for working in a team based on actionable approach, which proposes to integrate classroom and extracurricular activities and use pedagogical technologies to develop communication skills and discover the personal potential of a future IT-specialist for team interaction;
- during the process of team formation, psychological particularities of students are exposed, which helps to develop their communication skills, ease psychological stress and emotional stiffness;
- pedagogical technologies are actively implemented: collaboration pedagogics that allow to productively organize collaborative workflow of students to form positive interpersonal relations, develop cognition activity, independence, communication skills, collective work, which, in the end, contribute to development of personal qualities of students, expansion of the potential of future IT-specialists in conditions of cooperation, mutual help, tolerance; game technologies that contribute to reduction of psychological pressure and stiffness, increased motivation, active and benevolent interactions, return to natural communication; project activity of students that contributes to involvement of students into active independent research activity, realization of practical teamwork skills, activation of creative endeavor.

The formulated conditions were considered during the development of a unique program for applied bachelor's degree on the subject of Information Systems and Technologies. Realization of students' project activity that is directed towards formation of abilities required to solve professionally-oriented tasks was accounted for in the form of course works and/or projects carried out by small student groups, complex graduation qualification work, as well as internship.

The implementation of project activities of students can be carried out in the form of term papers and / or projects, final qualifying works as well as in the process of internship.

Practice-oriented learning is one of the most important strategic tasks of the Institute of Information Technologies and Telecommunications of the North Caucasus Federal University. For a number of years, the industrial partner of the university has been the StilSoft group of companies, whose one of the main goals of cooperation was to obtain highly qualified IT specialists in the near future who know the specifics of the enterprise's activities from the student's desk. To achieve this goal the Institute of Information Technologies and Telecommunications launched a unique project in 2015 to train specialists for the StilSoft group of companies: an applied bachelor's group was set up in the area of training 09.03.02 «Information Systems and Technologies». The peculiarity of this group of students is the availability of the distributed practice training in the curriculum: one day a week, starting from the first year, students visit the basic enterprise, get acquainted with the projects carried out by the enterprise, and are actively involved in the production cycle of the enterprise. As part of the practice, students of applied bachelor degree are involved in projects implemented by the largest enterprise in the region, which gives students confidence and starts a career of a qualified specialist.

In the first year in the «Introduction to the specialty» discipline, students of applied bachelor degree were acquainted with the main activities of the largest enterprise in the region. Heads of departments involved in solving problems related to the main activities of the company presented the projects implemented by their departments to the students. After that, each of the students chose the direction that most closely coincided with the sphere of their professional interests: programming, design, modeling, and radioelectronics. Students

did practical work in several departments, tried themselves in different directions, trying to find the one that would allow them to reveal their full potential.

At the company’s training center, students studied equipment and software for all subsystems of an integrated security and control system developed by the company’s specialists. In the department of electronic equipment development, students of applied bachelor degree acquired the skills of designing elements of electronic equipment. In the department of unmanned aerial vehicles development students of applied bachelor degree not only studied the theoretical foundations of designing unmanned aerial vehicles, the basics of flight and autopilot programming, but also acquired practical skills in creating models of unmanned aerial vehicles. In the department of special software development, students acquired professional skills in implementing applications. Students acquired practical skills of design and modeling in the design department of the company.

The formation of most of the professional competencies of students takes place within a basic enterprise under the guidance of highly qualified specialists, where students solved specific applied tasks (for example, developing an interface for transmitting data from temperature sensors; developing a board for testing alarm loops; developing an application for internal corporate interaction, etc.) in the framework of projects implemented by the company.

The final stage of the teamwork competency formation of is the implementation of a comprehensive graduation qualification work «Design and development of the instrumental support of the balancing robot control system» by the group of students under the leadership of leading specialists of the basic enterprise. The topic of work is due to the need to create a two-wheeled mobile balancing robot for the implementation of academic objectives of the «Virtual Worlds» educational center and the «Robotic Systems» educational-scientific laboratory of the Institute of Information Technology and Telecommunications, in which students take an active part. A generalized functional model of the project in progress is presented in Fig. 1, the information model of the project – in Fig. 2

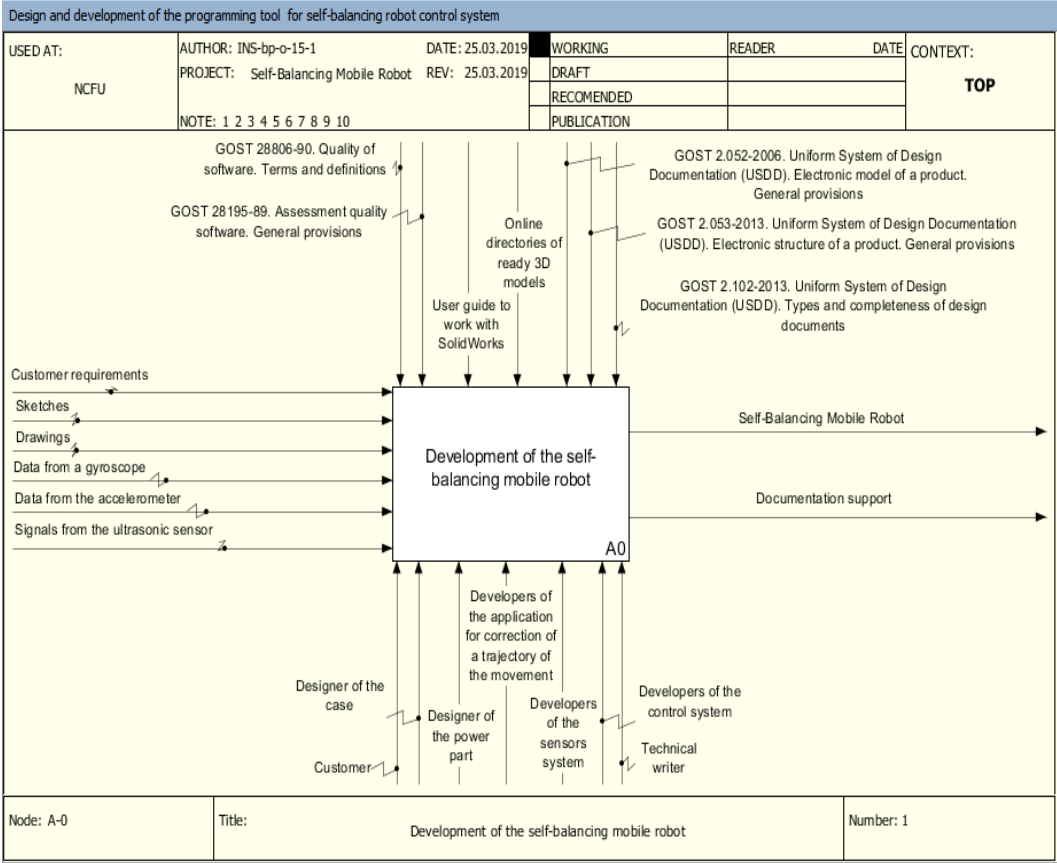


Figure 1: The generalized functional model of the project

## 4 Results

The project activity of students consists of several stages, presented in Tab. 1, consistently improving such competencies as the ability to search for information, critical analysis and synthesis of information, applying a systematic approach to solving problems, determining the range of tasks within the framework of the goal and choosing the best ways to solve them based on existing legal norms, available resources and limitations to carry out social interaction and realize their role in the team, actualizing the independent work of the student on the problem situation.

At the preparatory stage of the project implementation, tasks and roles in the team were distributed:

1. Project supervisor: management (planning, workflow organization, monitoring and deviation analysis), organizing and implementing communication between project participants.
2. Designer: creating a model of a balancing robot.
3. Designer: designing the hull of the balancing robot.
4. Designer: design of the power part of the balancing robot.
5. Developer: creation of a sensor system (programming the sensors).
6. Developer: creation of a sensor system (programming of the system clock, configuration of the UART / IO / DMA module).
7. Developer: creation of a robot control system.
8. Developer: creating an application for adjusting the robot's movement trajectory (interface development, development of a data visualization module, development of a module for setting up a PID controller).
9. Technical writer: preparation of documentation.

Since both the planning and level of communications play an important role in the work of the team and significantly determine the success of the project, various services were analyzed during the preparatory stage to plan and manage the team work, build online diagrams, etc. so that team members could work much more efficiently. The functionality of such web-services as Jira, Trello, Slack, GanttPro, Teamwork, GitHub, Basecamp were considered.

Interaction between all project stakeholders, including the customer, users and project team members, was carried out using the Basecamp online service, which is designed for people to collaborate on projects, allowing to share documents, conduct discussions with the team, create to-do sheets and add comments to tasks and send and receive email.

Table 1 Stages of project activity.

Stages	Tasks	Categories of competencies
Preparation	Formulation of the topic and relevance of the study. Identifying problems and their components. Designation of the object and subject of study. Goal setting. Creating a team, choosing a leader, assigning roles to a team.	Systematic and critical thinking. Development and implementation of projects. Teamwork and leadership.
Planning	Detailed analysis of the problem (causes, signs, methods of solving). Definition of work structure.	Development and implementation of projects.
Realization	Selection of material. Performing project tasks. Formulation of conclusions.	Systematic and critical thinking. Development and implementation of projects. Teamwork and leadership.
Presentation	Demonstration of the project. Providing reporting documentation in accordance with the established requirements.	Systematic and critical thinking. Development and implementation of projects. Teamwork and leadership.
Reflexion	Grading the result.	Systematic and critical thinking.

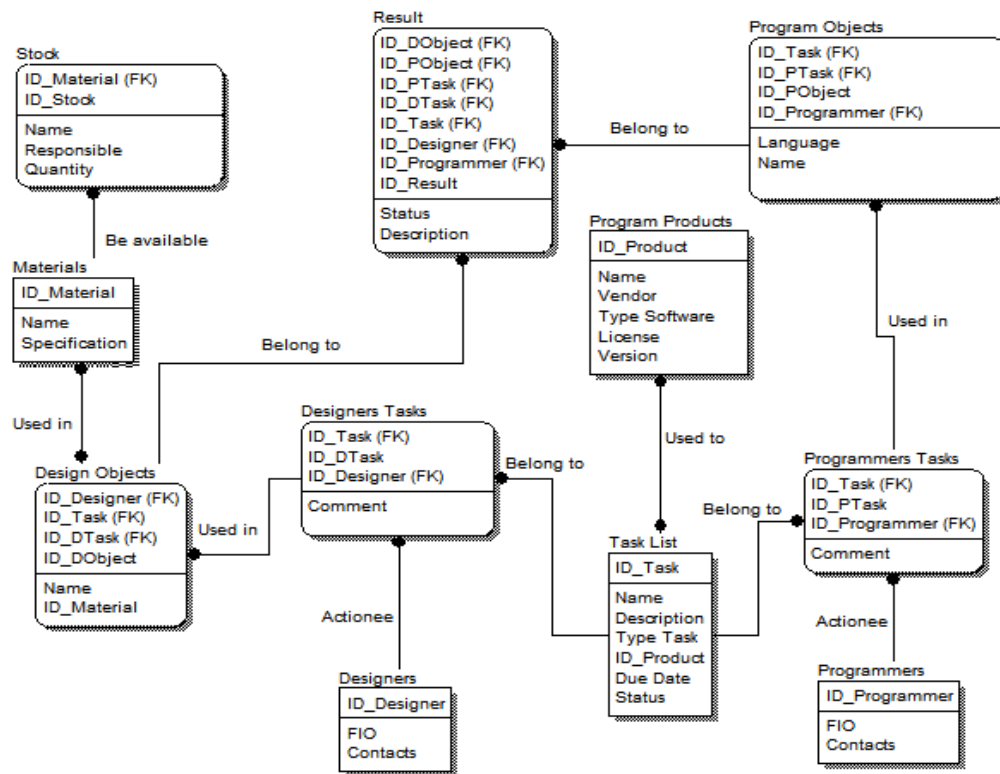


Figure 2: Informational model of the project

Tasks and roles in the team are presented in Fig. 3 as a decomposition of the first level and a diagram of use cases (Fig. 4).

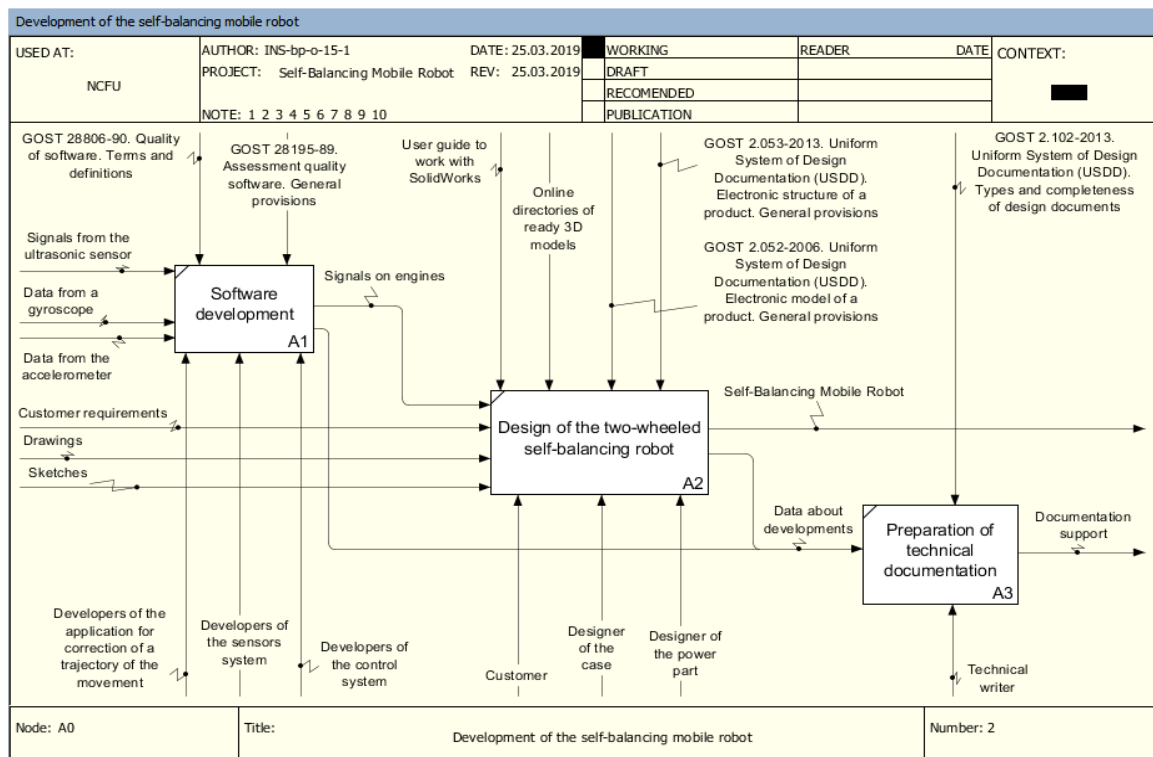


Figure 3: First level decomposition

## 5 Discussion

The level of formation of key competencies of project activities of students can be assessed by the degree of development of individual personal qualities and professional abilities, which are presented in Tab. 2 as indicators of the achievement of competencies.

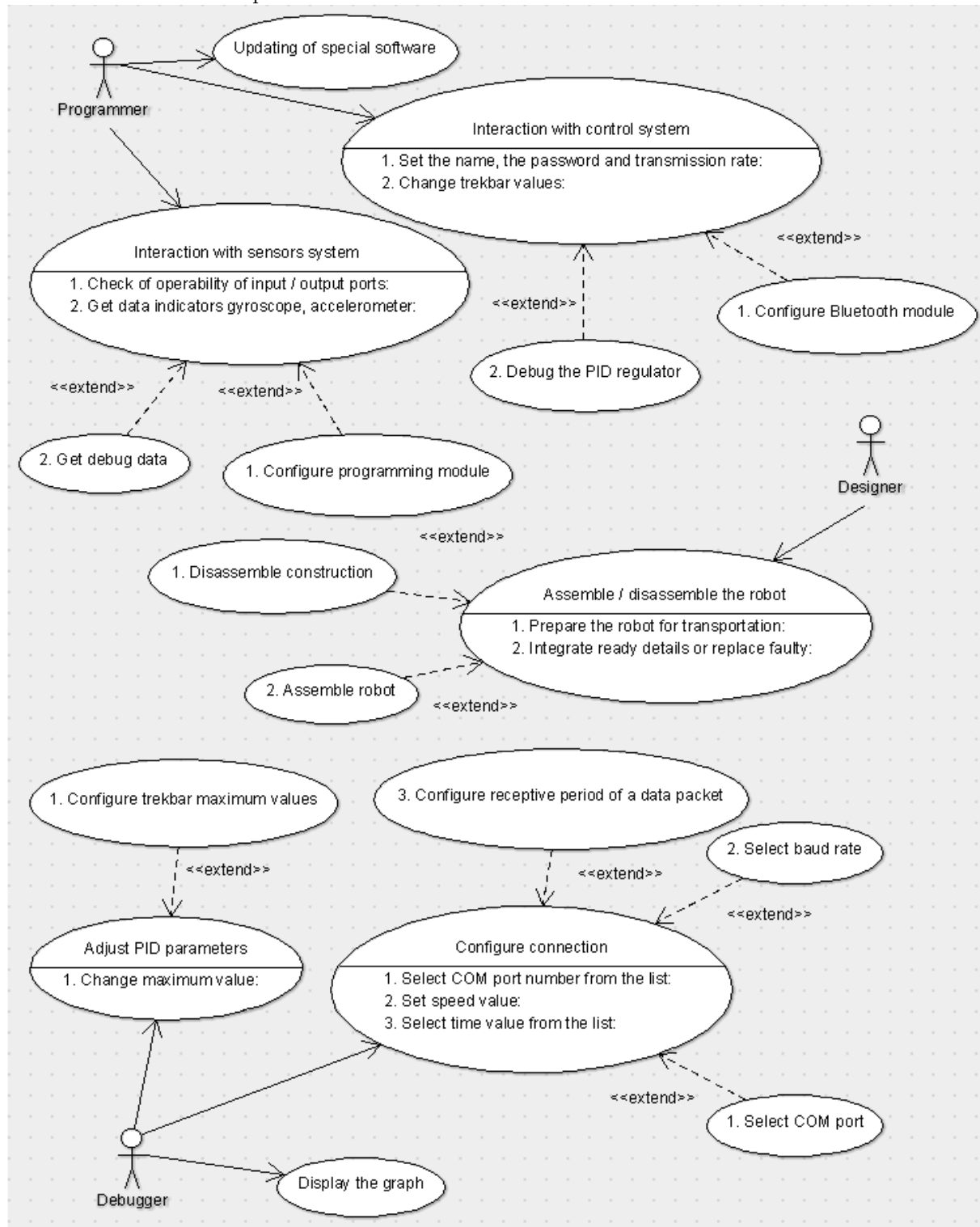


Figure 4: Usage case diagram

Table 2 Indicators of achievement of key competencies of project activities.

Competence of the project activities	Competence achievement indicators
The ability to search, analyze and synthesize information, apply a systematic approach to problem solving	<p>Analyzes the task, highlighting its basic components, carries out the decomposition of the task.</p> <p>Finds and critically analyzes the information needed to solve the problem. Considers possible solutions to the problem, assessing their strengths and weaknesses.</p> <p>Competently, logically, convincingly forms its own judgments and evaluations. Distinguishes facts from opinions, interpretations, assessments, etc. in the arguments of other participants in the activity.</p> <p>Defines and evaluates the consequences of possible solutions to the problem. Reflects as an awareness of the reasons for their actions</p>
The ability to determine the range of tasks within the framework of the goal and choosing the best ways to solve them based on the existing legal norms, available resources and restrictions	<p>Formulates a set of interrelated tasks ensuring its achievement within the framework of the project goal.</p> <p>Determines the expected results of solving selected tasks.</p> <p>Designs a solution to a specific problem, choosing the best way to solve it based on current legal norms and available resources and constraints.</p> <p>Solves specific problems of the project of the declared quality and for the established time.</p> <p>Publicly presents the results of solving a specific project problem.</p>
The ability to carry out social interaction and realizing own role in the team	<p>Understands the effectiveness of using the strategy of cooperation to achieve the goal, determines its role in the team.</p> <p>Understands the behavior of selected groups of people with whom they work / interact, considers them in their activities.</p> <p>Anticipates the results (consequences) of personal actions and plans a sequence of steps to achieve a given result.</p> <p>It effectively interacts with other team members, including participating in the exchange of information, knowledge and experience, and the presentation of the team's work results.</p>

The interdisciplinarity of the project idea creates conditions for self-realization of the individual through the development of intellectual abilities and creative abilities, which contributes to the formation and development of not only universal competences, but also helps the specific thematic focus of the project work to find the students the best answer to a practically important question for them [Flo18].

The project activities of students can be implemented within a specific educational discipline, and can also serve as a method of organizing, monitoring and controlling independent activities of students in the context of the educational process of the university. In this case, the fundamental idea of integrating the project activity into the learning environment becomes the development of an individual educational route taking into account the capabilities and needs of students, as well as the specifics of the training direction.

Working on the project involves close interaction between the student and the teacher. In this regard, there are two extremes – on one hand, to fully provide the students to themselves or on the other, to significantly limit their independence by constantly interfering, directing, advising – thus reducing the students' initiative. The pedagogical subtlety consists in making the students feel that the project is their own work, creation, invention and realization of their own ideas and intentions. Students should see that the teacher respects their point of view, even if it does not coincide with the point of view of the teacher.

Modern conditions of the educational process at a higher education institution should provide for individualization of education, which should be understood as «a way to ensure each student has the right and opportunity to form their own educational goals and objectives, their educational trajectory» [Ste13]. Designing and implementing an individual educational trajectory, taking into account personal capabilities and aspirations, will allow the student to form precisely those qualities that are currently most demanded by society.



## 6 Conclusion

Thus, the project activity plays a decisive role in the formation and development of the competence to carry out social interaction and realize own role in the team. Also team work on the project contributes to the formation of such universal competencies as the ability to search, critical analysis and information synthesis, applying a systematic approach to solving tasks, determining the range of tasks within the framework of the goal and choosing the best ways to solve them based on current legal norms, available resources and limitations.

## References

- [Bar17] Baranova T.A. Integration of project activities of students in the educational process of the modern university. *Sovremennye naukoemkie tekhnologii [Modern high technologies]*, 2017, no. 9, pp. 88-89.
- [Men19] Menekse, M., Purzer, S., Heo, D. An investigation of verbal episodes that relate to individual and team performance in engineering student teams (2019) *International Journal of STEM Education*, 6 (1), article No. 7.
- [Gom19] Gomazov, F.A., Burlov, V.G., Byzov, A.P., Andreev, A.V. Principles of Creation of Youth Organizations in Teaching the Basics of Project Work (2019) *Proceedings of 2018 17th Russian Scientific and Practical Conference on Planning and Teaching Engineering Staff for the Industrial and Economic Complex of the Region, PTES 2018*, article No. 8604250, pp. 82-85.
- [Jär10] Järvelä, S., Hurme, T.-R., Järvenoja, H. Self-regulation and motivation in computer-supported collaborative learning environments (2010) *Learning Across Sites: New Tools, Infrastructures and Practices*, pp. 330-345.
- [PMI08] A Guide to the Project Management Body of Knowledge. – Newton Square, Pa: Project Management Institute, 2008 - . 468.
- [Dau15] Dautova O.B., Ivanshina E.V. Modern pedagogical technologies of the main school in the conditions of the Federal State Educational Standards. Saint Petersburg, KARO Publ., 2008, 176 p.
- [Smi16] Smirnova I.N. Organization of project activities of students in the new educational standard. *Izvestija VGPU [Bulletin of the VGPU]*, 2016, 4 (273), pp. 44-47.
- [Cas18] Castro, S.J., Jácome, L., Concha, A.G., Vásquez, J., Londa, G., Córdova, L., Vintimilla, B., Abad, C.L., Miño, M.F., De Lourdes Pilay, M. An Undergraduate Project combining Computer Science and the Arts An Experience Report of a Multidisciplinary Capstone Design (2018) *ACM International Conference Proceeding Series*, pp. 1-8.
- [Anw18] Anwar, S., Menekse, M., Heo, M.D., Kim, M.D. Work in progress: Students' reflection quality and effective team membership (2018) *ASEE Annual Conference and Exposition, Conference Proceedings, 2018-June*.
- [Pan18] Pankratova O.P., Konopko E.A., Nemkov R.M., Mezentseva O.S. The preparation of a modern computer science teacher with the help of resource-saving technologies and green it implementation (2018) *Integrating Research Agendas and Devising Joint Challenges. International Multidisciplinary Symposium ICT Research in Russian Federation and Europe*, pp. 222-228.
- [Flo18] Flores-Parra, J.-M., Castafon-Puga, M., Evans, R.D., Rosales-Cisneros, R., Gaxiola-Pacheco, C. Towards Team Formation Using Belbin Role Types and a Social Networks Analysis Approach (2018) *2018 IEEE Technology and Engineering Management Conference, TEMSCON 2018*, article No. 8488386
- [Ste13] Stefanou, C., Stolk, J.D., Prince, M., Chen, J.C., Lord, S.M. Self-regulation and autonomy in problem- and project-based learning environments (2013) *Active Learning in Higher Education*, 14 (2), pp. 109-122.
- [Gom19] Gomazov, F.A., Burlov, V.G., Byzov, A.P., Andreev, A.V. Principles of Creation of Youth Organizations in Teaching the Basics of Project Work (2019) *Proceedings of 2018 17th Russian Scientific and Practical Conference on Planning and Teaching Engineering Staff for the Industrial and Economic Complex of the Region, PTES 2018*, article No. 8604250, pp. 82-85.

- [Gal10] Galand, B., Raucent, B., Frenay, M. Engineering students' self-regulation, study strategies, and motivational beliefs in traditional and problem-based curricula (2010) *International Journal of Engineering Education*, 26 (3), pp. 523-534.
- [Fri19] Friedrichs, J., Ohly, S. We don't like each other but still work together – how task interdependencies influence the relationship between interpersonal team processes and team satisfaction (2019) *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie*, 50 (1), pp. 15-24.
- [Cos18] Costa, A.C., Fulmer, C.A., Anderson, N.R. Trust in work teams: An integrative review, multilevel model, and future directions (2018) *Journal of Organizational Behavior*, 39 (2), pp. 169-184.
- [Gar18] Garibay, M.T., Gomez, J.C., Terissi, L., Soria, L., Marcuzzi, R., Moya, M., Bertinat, L., Massetti, A., Neumann, L., Chavarini, A. Space maker: A place where creativity, innovation and hands-on learning join to improve engineering education (2019) 2018 World Engineering Education Forum – Global Engineering Deans Council, WEEF-GEDC 2018, article No. 8629716.
- [Deg19] Degreef, P., Thiebaut, S., Van Merode, D. Practice Enterprise Concept Mimics Professional Project Work: Integration of on the Job Training in an Academic Environment (2019) *Advances in Intelligent Systems and Computing*, 917, pp. 372-380.
- [Ser18] Sereti, M., Mavropoulou, A., Stylianidis, P., Politopoulos, N., Tsiatsos, T., Douka, S. Design, Creation and Evaluation of TEAM, A Serious Game for Teamwork Development (2018) *Advances in Intelligent Systems and Computing*, 916, pp. 743-754.
- [Mar16] Marek, J., Benko, P., Chvála, A., Kósa, A., Pribytný, P., Stuchlíková, L., Donoval, D. The secret of successful student team project (2016) 11th European Workshop on Microelectronics Education, EWME 2016, article No. 7496468.
- [Kam12] Kamarudin, S. K., Abdullah, S. R. S., Koffi, N. T., Rahman, N. A., Tasirin, S. M., Jahim, J., & Rahman, R. A. Communication and teamwork skills in student learning process in the university (2012) *Procedia-Social and Behavioral Sciences*, 60, pp. 472-478.
- [Fra03] Frank, M., Lavy, I., Elata, D. Implementing the project-based learning approach in an academic engineering course (2003) *International Journal of Technology and Design Education*, 13 (3), pp. 273-288.