

# A project-based learning approach to teaching software engineering through group dynamics and professional communication

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**Abstract:** The using of a project-based learning approach to teaching students still causes a lot of disputes and disagreements. This learning approach allows to minimize the set of the necessary theory and increases the number of practical activities. We applied project-based approach for teaching 150 software engineering students simultaneously. The article shows how to apply project-based training on large group of students and gives examples of typical mistakes in such teaching approach.

**Keywords:** project-based learning approach, learning approach, teaching software engineering

# 1 Introduction

In article the fundamentals of course “Group dynamics and communication in professional practice of software engineering” are described. This course is taught to 2nd year undergraduate students (09.03.04 Software engineering) and consists of lectures (38 hours), seminars (38 hours) and time for self-study (114 hours). This discipline is based on students' knowledge of the fundamentals of software development process and the experience of individual developing of software programs during the 1st year of study.

Now it is not a secret that the labor market is changing faster than it was 30-40 years ago. This is due to the rapid growth of technology and the increase of knowledge and skills in the world. The growth in the field of information technology (IT) is particularly noticeable. Approximately every six months something radically new appears in the sphere. It leads to the fact that it is impossible for one person to achieve a good result in IT. Most of the software products that we use today have been written by large cross-functional teams. Therefore, teamwork skills are becoming critical success factors in the software development industry. As a result, teaching students to IT and teamwork skills is a relevant need in the labor market [1].

The key component of the course is a main team project. The project is carried out by small groups of 3-5 students and implemented for a customer who has not an experience in the IT industry. The goal of such project is to guide students through the software development life cycle (SDLC), to immerse them into the actual practice and to develop their competencies.

Our mission from the teacher's point of view is to make our students being competitive in the labor market through the formation of a holistic understanding of the status, mechanisms and foundations of the productive activities of project teams in the SDLC.

Main objectives of the course are:

- To develop the skills of project team formation.
- To develop the teamwork skills.
- To learn the basics of human resource management and communication in the project.
- To enable practical application of acquired knowledge, skills and competencies in professional practice.
- To give an opportunity to work in a real project with a real customer.

The description of the course in this article is divided into four parts (theoretical, self-knowledge, teamwork skills, main project development). Comprehensive assimilation of the material is achieved through the parallel implementation of all parts of the course.

In the course the different educational technologies are used (peer review [2], flipped classroom [3], online testing, collaborative space for working [4], project planners, case studies and business games).

The key stakeholders of course can be highlighted:

- students;
- teachers;
- customers;
- teaching assistants.

In article the description of all parts of course is given. Various educational technologies are used. The interaction between the main stakeholders are described. The main steps of main projects are highlighted. Finally, the problems with projects and common mistakes are mentioned.

## 2 Classroom activities

Classes (lectures and seminars) are held using various electronic educational technologies. These technologies allow to involve students in the learning process.

### 2.1 Syllabus

As noted above, the course is aimed at the practical component. However, students should learn the basics of software development for the successful completion of the main project. Below the list of lecture topics is presented:

- Overview of the most known and state-of-the-art IT technologies and market trends.
- The software development life cycles.
- Competitor and subject analysis.
- Software Requirements: identification and analysis.
- Overview of project management tools (YouTrack, Trello, Jira, etc.)
- Techniques of task time estimation and planning.
- Design thinking and prototyping. How to make a useful product?
- Git: distributed version control system.
- Brainstorming and its rules.
- Software architecture. An overview of good practices and basic patterns.
- The role of testing in development.
- Risk management, risk planning. Prevention and response plans.

- Retrospective. What is it and how to carry it out correctly?
- The basics of a perfect pitch.

## **2.2 Engaging practitioners**

It should be mentioned that several lectures were given by practitioners, specialists in their field and company representatives. So, in addition to the lectures described above, the following reports were held:

- Lecture on project management tools.
- Lecture on interface design.
- Lecture on Git technology.
- Lecture on risk management.

## **2.3 Usage of online technologies**

Unfortunately, the problem of poor absorption and memorization of material is very popular. One of solutions is a frequent practice that usually contributes to rapid memorization. On the course services described below are used. Some of them allow to quickly conduct online tests in the class. Another (MS Teams, Trello, Gitlab Project) allow to students organize their inter-team communications and help organize teamwork.

### **2.3.1 Kahoot**

Kahoot is a service for creating online quizzes, tests and surveys. Kahoot is a game-based classroom response system played by the whole class in real time. Multiple-choice questions are projected on the screen. Students can respond to the questions from any device with access to the Internet. Tasks created in Kahoot allow to include photos and even video clips. The pace of the quiz is regulated by introducing a time limit for each question. Also, it is possible to enter points for the answers to the questions posed: for the correct answers and for speed. To participate in the test students simply need to open the service and enter the PIN code that is shown on the slide prepared by teacher [5].

### **2.3.2 Quizizz**

Quizizz is a free tool. It works on any device: web browser, iOS, Android and Chrome apps. Everybody can access hundreds of ready-made learning quizzes or create your own. Teachers can join, pick a quiz, and use the code for a virtual room to give to students. Just like Kahoot, the teacher (or student host) chooses a quiz to begin. However, the question order is randomized for each student, so it's no easy for players to cheat. With Quizizz, players don't have to wait for the whole class to answer a question before they continue to the next one [6].

### **2.3.3 Microsoft Forms**

Microsoft Forms is an Office 365 tool which provides an opportunity to a teacher to easily and quickly create online custom tests, surveys, questionnaires, registration forms etc. The responses from users can be processed using the built-in analysis tools. Formed data, such as test results, can be easily exported to Excel for additional analysis or evaluation [6].

### **2.3.4 Socrative**

Socrative allows to conduct tests in real time, while students respond using their devices. Socrative is one of the most popular platforms for creating mobile surveys, allowing to create various types of questions and download reports with student answers. The obvious advantage of Socrative is that students can see the questions on their devices. This service differs from Kahoot, which display questions only on the teacher's monitor. At Socrative, a teacher can add clarification to each question. It may appear immediately after the student has answered the question, which makes immediate feedback possible. You can add tags to tests to make them easier to find. Students can complete the test at their own pace. It is possible to skip the question or even change the answer before sending the test to the teacher. In Space Race mode, students or groups of students can compete who quickly answers more questions correctly [7].

### **2.3.5 PeerGrade**

It is not possible to quickly evaluate the works of the large number of students. Peer review using the PeerGrade service is carried out for a quick assessment as well as to improve understanding of some topics. Students upload their work, get evaluation criteria and three works of other students and then evaluate them according to the given criteria. It is worth noting that the teacher still must check 10% of the best homeworks, 10% of the worst homeworks as well as 10% of random jobs [8].

### **2.3.6 Pear Deck**

Pear Deck is a service that allows teachers to design presentations with built-in assignments and display them on any device. The teacher switches the slides on their own computer (or tablet) and students view the presentation on their devices, answer questions and complete tasks. Answers can be displayed on the big screen in real time. A distinctive feature of presentations created using this service is the ability to provide students with immediate real-time feedback. Listeners can set up the level of “comprehensibility” of both the current slide and the material as a whole [9].

### **2.3.7 MS Teams**

Collaborative course space is organized in MS Teams. Microsoft Teams is a unified communications platform that combines persistent workplace chat, video meetings, file storage (including collaboration on files), and application integration. One of its part is MS OneNote which has great functionality that is useful for educational purposes. In our discipline, this resource was used for the exchange of content between students and teachers – each student and each group had individual tabs that were visible only to them and to teachers, where they submitted their homework. Also, the resource allows to exchange lecture and seminar materials with students, maintain a list of homework on the course. And most importantly, the teachers have their own section, where you can store your private materials that will not be visible to others [10].

### **2.3.8 Trello**

In the course students have the opportunity to independently choose the software solution, where the project will be conducted. The most popular solution is Trello, where the teacher can have an access, so it becomes possible to track the progress of the project. Trello is a small project management program developed by Fog Creek Software. Trello uses a project management paradigm known as Kanban, a method that Toyota originally popularized in the 1980s for supply chain management.

### **2.3.9 Gitlab Projects**

GitLab is a web-based DevOps lifecycle tool that provides a Git-repository manager providing wiki, issue-tracking and CI/CD pipeline features, using an open-source license. Students keep their projects in the remote repositories providing by GitLab. Also, GitLab allows to plan, organize, and track project progress with issues, labels, weights (story points), milestones (sprints and releases), time tracking, due dates, and assignees using Scrum, Kanban, SAFe, and other methodologies [11].

## **3 Self-study**

During the course students put through eight different tests aimed at self-study, identification of leadership style, the role in the team, etc. Passing tests helps students to determine their role in the team. It is known that there are a lot of different psychological types of people, and for some types of them it is not recommended to work together. Students learn these aspects in the process of passing self-knowledge tests.

### **3.1 Test description**

This section provides a brief description of the tests that students are passed. These tests are well-known and can be found on the Web.

#### **3.1.1 The Thomas Kilmann conflict mode instrument**

This is a questionnaire consisting of 30 pairs of claims. The technique is designed to study a personal predisposition to conflict behavior and to identify certain styles of conflict resolution. This test can be used as a guideline for studying the adaptive and communicative characteristics of a person. This questionnaire shows a typical human reaction to a conflict and also provides information on other possible ways to resolve a conflict situation [12].

#### **3.1.2 Belbin’s team roles**

R. Belbin identified 8 types of human roles in the team depending on personal characteristics and qualities: resource investigator, team worker, coordinator, plant worker, monitor evaluator, specialist, shaper, implementer. It is important for each student to understand their preferred role in the team without choosing an obviously inappropriate or conflicting position in the group [13].

#### **3.1.3 Myers-Briggs type indicator**

The Myers-Briggs Personality Type Test (MBTI) is designed to identify one of 16 personality types. It includes 8 scales combined in pairs (Extraversion - Introversion, Sensing - iNtuition, Thinking - Feeling, Judging - Perception). The purpose of the typology is to help a person in determining of individual preferences by establishing which poles of the scales correspond to him [14].

### **3.1.4 Leadership test**

Leadership test (by R.S. Nemov) is designed to assess a person's ability to be a leader without detailing type or level. Leadership is revealed by this test without taking into account details of the situation where the leader must act. The test consists of 50 questions with two possible answers (Yes or No). Students should understand that a team composed of leaders with more than half is less competitive.

### **3.1.5 Emotional Intelligence test**

Emotional Intelligence Test (EQ Test) is one of the most common methods for diagnosing emotional intelligence, including self-diagnosis. The test, developed by Nicholas Hall, helps to determine the level of emotional intelligence in several ways. Student receives not a single point as in classical IQ test but a differentiated mark for each of the five characteristics highlighted by the author. In total, students past test of 30 questions with 6 of them in each category [15].

### **3.1.6 Type of conflict style**

The test for personal effectiveness and proneness to conflict consists of 80 statements. It is designed to identify the propensity of the subject to make a conflict and to be aggressive. The following diagnostic scales are used in the methodology: temper, offensiveness, resentment, intransigence, compromise, revenge, intolerance to the opinions of others and suspiciousness [16].

### **3.1.7 Thinking Styles**

The questionnaire "Thinking Styles" consists of 80 questions and is designed to determine the preferred style of thinking, the manner of asking questions and making decisions. Under the style of thinking we understand an open system of intellectual strategies, techniques, skills and operations (from the system of values and motivation to characterological properties) [17].

### **3.1.8 Questionnaire on emotional intelligence (Emin)**

The emotional intelligence questionnaire (Emin) consists of 46 statements. The questionnaire has been developed over the past few years. The early stages of its development have already been described previously (Lyusin, Maryutina, Stepanova, 2004; Lyusin, 2006), the final version was published in 2006 (Lyusin, 2006). The questionnaire determines the level of development of emotional intelligence on four scales: the ability to understand other people's emotions and manage them (interpersonal emotional intelligence); the ability to understand own emotions and manage them (intrapersonal emotional intelligence); the ability to understand own and others' emotions; ability to manage own and others' emotions [15].

## **3.2 The purpose of tests**

Self-knowledge is an important process in this discipline. Students pass tests and prepare a small report for each of them that includes answers on the following questions: "What features and characteristics do you consider positive in the context of your life and career growth?", "What features and characteristics do you consider negative in the context of your life and career growth?", "How can you change or improve features that do not make you better?". Introspection helps students determine their preferred role in the team. In the process of team building students tell everyone their preferred roles. This facilitates the process of team building.

## **4 Game-based development of teamwork skills**

Teamwork is a difficult process, especially for 2nd year students. Business games are incorporated into the course in order to prepare them for teamwork. Games are aimed at development of communication and planning skills, etc. The business games that were used in the course are described below [18].

### **4.1 Giovanni's secret**

Students play this game in the same teams which they make their main project. In order to make the game more interesting, several teams are combined into one game group. The group sits in a circle. Participants receive various information in form of text cards. The secret will be solved only when the whole group concentrates on the work, begins to carefully listen to each participant and takes seriously what other say. Each participant receives several cards (usually 2) with some information. In order to find a solution, the group must bring together all the information on the cards. Participants can't record or write anything. Students cannot force others to read what is written on his or her card if he or she does not want to do it. No one can show his or her card to another participant and ask questions to the facilitator. The team must give an answer in 25 minutes.

This game is similar to Einstein's riddle, which is solved only by 2% of people, according to statistics. The complexity of the game is connected with the fact that, as a rule, in such groups there are more than two potential leaders, and if they are strong enough, then it is difficult for team to come to a common decision. Also, contradictions arise between the participants. Also, it should be noted that an attempt to read all sheets of information is unsuccessful - someone either interrupts or begins

to ask questions. So, it can be difficult to come to a consensus: conflicts and controversial situations arise, each member of the team is trying to “pull the blanket.”

After the business game the following issues are discussed:

1. How did the group organize their work?
2. How was the information contained in the cards used?
3. Have all participants submitted their information to the rest?
4. What was the atmosphere during the game?
5. Have all the proposals been seriously considered?
6. Did someone alone have a conversation at some time?
7. What could have gone better than gone?
8. What conclusions did you personally draw from this experiment?

This game shows that making decisions in a team is not an easy process, and each team member is responsible for making the wrong decision.

## **4.2 Adaptation of Martians to Earth conditions**

In order to learn the Scrum framework, it is best to directly apply it in practice using a game case. Rules are as follows. Martians go on an excursion to Earth. Students are formed in groups, which are different travel companies that are going to participate in a tender for the possibility of conducting excursions for Martians on Earth. To participate in the tender, they need to create a presentation album (advertising brochure) to demonstrate 5 places on Earth where they plan to organize an excursion for them. The teacher plays the role of Product Owner. In some sprints, the teacher unexpectedly changes the requirements: between the teams there is a mutual exchange of participants or already drawn advertising brochures (modeling situations in companies), bans on some countries appear, wishes are introduced for the specific colors of the markers used in the drawings, etc. Time for planning Sprint - 3 minutes. Sprint time is 7 minutes. The time to demonstrate the project to the product owner and summarize the sprint is 3 minutes. Teams have limited resources (scissors - 1 pc. for 3 teams, multi-colored felt-tip pens - each color 1 pc. for 3 teams, glue stick for paper - 1 pc. for 3 teams). Each team also has unlimited resources (paper, self-adhesive stickers, planning board). Totally, there are only 5 sprints. In the end of the last sprint teams make a presentation of their solution.

Finally, it is necessary to conduct a retrospective with the following issues:

1. What do you think of the past game?
2. What got in the way?
3. What helped?
4. What can be improved?
5. What are your lessons learned?

This game is aimed at understanding the Scrum framework – the most commonly used framework for developing IT projects.

## **4.3 Snowflake**

Students are divided into teams (they are the same as in main project). In the case of a small number of people in the team (3 persons or less), the teams are combined. Thus, in each game team should be 4-6 people. Each formed team must create and sell snowflakes cut out of paper. It is necessary to choose those students who fulfil the role of buyers (approximately 3 buyers for 6 formed teams). Buyers and teams are briefed and then the game begins. The task of the teams is to cut out snowflakes from paper and try to sell them to customers as expensive as possible. However, the essence of the business game is that buyers receive secret instructions about what forms of snowflakes they should buy and at what price. The team that earned the most amount of money in 5 rounds wins. This game fulfils the ability to observe and understand what the client wants.

Rules for teams:

Each team of 4-6 people has 1 pair of scissors, 5 A4 sheets, 3 monetary units. An extra pair of scissors costs 8 units. Each additional A4 sheet costs 4 units. Round 1 consists of 3 minutes for cutting snowflakes and 3 minutes for sale. There are only 5 rounds. Buying resources is possible only in between rounds. The goal is to earn as many monetary units as possible during the game.

Rules for buyers:

Buyers should behave the same way as in life – they do not buy what they do not like, and they do not succumb to aggressive sales. If the snowflake is not high-quality, for example, torn or dirty, they should tear and throw it away. Teams should be able to understand which snowflakes buyers like most of all through observation. Buyers should lay out the purchased snowflakes on the table in the order of their “importance”. Clients do not hide their preferences, so they should answer honestly if the team asks which snowflakes they like. The most important is that every buyer has his or her own preferences, for example, one buys only small round snowflake, another buys any snowflake that have its “own story”, etc. At the beginning of the game each customer has 40 monetary units.

Most important findings for retrospective:

1. You must find out what needs to be done (understand the requirements), and only then do the job.
2. Hard deadlines lead to the fact that we forget to look at the whole situation.

3. It is necessary to carefully study the behavior of consumers.
4. Customer time is limited, so it is very important to use it as efficiently as possible.
5. There is no need to make a lot of snowflakes in order to understand the needs of consumers.
6. The whole team should deal with consumer preferences. Salesmen do not always convey accurate information to manufacturers.
7. Sometimes it's more efficient not to try to solve the problem head on: don't sell to this particular customer, but try to sell it to another customer.

This simulation allows students to understand that customers do not always know exactly what they want. In addition, this game shows the importance of such a stage of the project as "Domain Analysis".

#### **4.4 Business game for the analysis of requirements**

It is necessary to form a team of 2-5 people (the teams must coincide with the team in the main project). Then these teams select one of the household items (for example, washing powder, gloves, a basin, etc.) and write five requirements for this subject using natural language. It is necessary for them to remember about such individual properties of requirements as simplicity, comprehensibility, atomicity, unambiguity, reachability, traceability, testability, correctness, measurability and necessity. In general, the set of requirements should be consistent, complete, modifiable, not redundant, and ranked in importance. At the next step, teams need to exchange requirements with another team and find inaccuracies in them, according to the criteria. After that they resubmit the results. The complexity of the business game is that even the simplest subject requires careful analysis and accuracy when writing requirements.

If the requirement is spelled incorrectly, this entails large financial losses (especially if it became clear after implementation). Therefore, this game is necessary to show students how to work with requirements and what typical mistakes exist.

#### **4.5 Business game to develop a test plan based on an interview with a QA engineer**

The team is given a simple pencil with an eraser at one end for 25 minutes. The aim is to describe the steps for comprehensive testing of the pencil. After the time has passed, each team should present its results. The pencil is not mechanical, but rather a simple one - wooden or plastic. Nothing is said about color - thus, a pencil can be colored. In fact, this condition only says that this pencil is more suitable for drawing than for simple notes. The following types of testing should be considered:

1. Primary testing.
2. Functional testing.
3. Quality assessment testing.
4. Performance testing.
5. Stress testing.
6. Ergonomic and usability testing.
7. Security testing.
8. ECO-testing.

The main evaluation criteria will consider the fulfillment / non-fulfillment of the conditions of these tests. If the test is performed, you can evaluate the result according to predefined rules (for example, on a ten-point scale, 0 - terrible, 10 - excellent). Some parameters must be represented in numerical terms. Based on the data obtained, it is possible to create summary characteristics of various pencil models. Teams should not forget to compile a bug-report while testing.

Testing is an integral part of any software product. Such a comic game allows us to understand the differences between different types of testing, as well as show the importance of testing.

#### **4.6 Business game "The highest tower" to develop planning and design skills Business game for the analysis of requirements**

It is necessary to build the highest tower of paper with maximum efficiency following the instructions received. 30 minutes are given for discussion and preparation. During preparation, it is necessary to draw a sketch (layout) of the future tower. During the game team can use each sheet of paper only once, that is, if the sheet of paper is somehow bent, then the team must take new sheet for the next experiments. Each team gets only 100 sheets of paper and 4 plastic cups. It is very important that the built tower must stand for at least 1 minute in order to be considered as "good" one. The peculiarity of the game is that after the layout of the future tower is completed, each team suddenly finds out that it should exchange mock-ups with another team and carry out the "construction" of the tower according to someone else's layout.

Questions for compulsory retrospective:

1. How was the discussion of the assignment?
2. How were the roles distributed in the team?
3. What did you like about the team performance? What didn't you like?
4. Did the goal set by the team coincide with the goal of the assignment set by the teacher?
5. Did all team members take all the parameters into account: time, height, materials?
6. What helped with the assignment?

This game is aimed at developing architectural principles. Despite the fact that the architecture of the software project is different from the architecture of the tower made of paper, this business game shows students that the incorrect construction of the architecture at the initial stage can lead to problems in the implementation of the project.

#### **4.7 Business game “Bamboo stick”**

The essence of this business game is as follows. First, one person lowers a long stick on the floor. He or she can do it with ease, in less than a minute. Then the team takes a stick, which is placed on the index fingers extended forward. The task of the team is to lower the stick to the floor so that it does not come off at the hands of all team members. In case the stick is separated from the team’s hands, the team starts again. The amazing thing is that, as a rule, this process takes 8-10 minutes.

This simple game is necessary to show how important the role of a leader in a team is. If a team does not have an explicit leader (or two people try to be leaders), then the team cannot come to success for a very long time.

### **5 Customers for main projects**

Each team must have a customer for the main training project. Customers can be divided into the following 6 categories:

1. Graduates of our faculty who work in leading IT companies.
2. Professors. Our students can help in the automation of many tasks (routine, research etc.), which is very interesting and beneficial for the university.
3. A lot of companies where students can have an internship in the future.
4. Personal teachers’ contacts.
5. Administrative staff with many topics, ideas and proposals that our students can implement.

Individual work with each potential customer was carried out in order to clarify the main essence of the project and obtain its description. We asked for a broad description of the idea and delivered it to our students in two or three paragraphs consisted of purpose and main functions explained in simple words.

Our customers were experts, consultants:

- devoting at least 1 hour 1 time per week for communication with the project team;
- participating in joint brainstorming for making better decisions;
- ready to talk about the requirements and wishes for the software product;
- who tested the prototypes made by the guys and gave the project team feedback on the value of certain decisions;
- who were present at the defense of the project and gave feedback on the work of the team and ready product.

### **6 The process of building the team for main project**

It should be noted that the course is held on a large stream (about 150 people). Teams are not formed by teachers, so each student decide for his or her own what team to join. However, there is a strict limitation - the formation of a team should take place in one student group only. It is due to the fact that teams defense homework and do group trainings aimed at developing the main project at seminars.

Students are invited to pass the tests and questionnaires described earlier, including the Belbin test to identify the team role, as well as choose their preferences for the role in the team based on their competencies or the desire to acquire or develop certain skills.

After that, students exchange the test results and their preferences within the team. They do this on their own, without the teacher’s participation. The teacher intentionally does not participate in the exchange of information between students, thereby facilitating interaction within the group.

At the same time, a document with a list of project topics is sent to students. Students independently join teams depending on different principles: on the topic of the project, on the principle of improving the team with the necessary competencies for development, or according to their personal interests.

Students fill out a form in which they indicate the 5 most preferred topics for development. Of course, if topic was an initiative of a team, other teams cannot choose it. The students’ choice of topics arranged in order of priority is justified by the decision to prevent possible conflicts when different teams choose the same topic. Also, in this way the issue with potential problems with the customer is resolved - in this case, students will be offered the next priority topic. Fortunately, this situation did not arise during the implementation of the course.

### **7 Stages of the project**

Student teams go through all following stages in order to complete their projects:

1. Subject domain analysis (DFD charting), competitor analysis and SWOT analysis. Team presentation of results and receiving comments from the teacher.
2. Meeting with the customer. Identification of goals, objectives and requirements. Drawing up an initial list of requirements and an interview protocol.
3. Peer-review requirements of two other teams. Getting feedback from teams and correcting requirements. Team presentation of requirements and receiving comments from the teacher.



4. Drawing up a plan of work for the project (with details in 3 days). Project management in one of the systems (for example, Trello). Team presentation of results.
5. Creating a prototype based on elicited requirements. Demonstration of the prototype to the customer and teachers.
6. Determination of the quality metrics of the developed project, that determine how well the product is developed.
7. Development of software solution architecture.
8. Brainstorming on the topic “Opportunities for monetization of the developed application”. Team presentation of results.
9. Drawing up a list of risks, the main and additional plan for their resolution.
10. Start of developing a software solution. Students develop code and maintain a repository using Git technology.
11. Drawing up a test plan for the developed software solution.
12. Making a list of conflicts that were in the team. Describing why there were conflicts, based on the psychological characteristics of team members.
13. Compiling a list of lessons learned and good practices gained during project development.
14. Preparing for pre-project protection. Drawing up the final document. Getting feedback from the customer.
15. Pre-defense team project. Receiving comments from teachers, the customer, and commission members. Finalization of the project for protection.
16. Protection of the project. Preparation for implementation, in case of its successful implementation.
17. Obtaining feedback from customers and students on joint work done.

The plan was developed with using SWEBOK [18].

Pre-project defense is carried out by teachers and teaching assistants 2 weeks before the final defense. They evaluate the project and its 20-minute demonstration according to the criteria that were developed jointly with students at one of the first seminars. Pre-defense allows students to understand their mistakes, work out in a speech, get comments and modify the project.

Project defense is carried out jointly with other teachers, teaching assistants, and customer representatives. In the final defense, special attention is paid to the developed product and project documentation. Teachers pay attention to whether the defects that arose during the pre-defense were corrected. The result of the defense is a detailed commentary on the project, as well as tips on the next steps (is it worth to be continued, what is worth to be improved, etc.)

## 8 Main difficulties

In the process of implementing projects various kinds of conflicts arose in the teams. Most of them were resolved quickly, sometimes with the help of teachers.

In teams that were gathered together according to the “principle of friendship” conflicts arose more often. Some participants ignored others and did not carry out their work on the project. In one team non-fulfillment of the duties by a member of the team led to the fact that the team abandoned this participant. So, the participant lost a team in the middle of the project. This situation was expected. According to the principles of team development: if one of the teammates does not fulfill the indicated amount of work, the team has the right to abandon the “loafer”.

Sometimes conflicts arose with the customer (for example, if he did not answer for more than 3 days). If it was not possible to establish a connection with the customer, then students reported to the teachers. If the teacher was not able to get in touch with the customer for a long time, then the teacher took on the function of the customer.

Initially, a change of project themes was not expected. So, students were forbidden to change the topic of the project. However, during the implementation of the projects, several teams realized that they overestimated their capabilities and took up too complex topics. In order to be able to defend the project, they were asked to change topics in the middle of the course. The other team that was assembled on the basis of the “friendship principle” did not have the required competencies for the implementation of the project. It realized this fact at the beginning of the journey, so they could successfully join to other teams.

As part of this course, attempts have been made to combat the “free riders”. The free-rider problem arises in teamwork when one or more team members evade their duties. “Free riders” use the results of their teammates, passing off the results of their work for their own or made in conjunction with them. They are a kind of “ballast” team. Students are rarely willing to work “for two”. In case someone does not work or does it badly, they independently take measures (up to the exclusion of a team member from the project). In particular, in one of the teams, at the post-rider’s mail there was a conflict that led to the participant leaving the team.

One of the biggest problems is the customer. Often customers expect a lot of things from students, they wrongly assume that students’ projects will be as big and mature as ones from Microsoft, Google, Amazon or other companies. It is worth considering that students only study and can develop a prototype, in rare cases - a finished product. Some customers lost contact and did not respond to students. This is the biggest problem that we are not able to solve and anticipate.

## 9 Conclusion

The main goal of this course was to explain students the rules of teamwork in the context of software development. Young and inexperienced students needed the guidance. So, the authors of this article tried to take on this role and tell students the

theoretical foundations of software development, its main stages and points worth paying attention to, the main teamwork tools used in the market and trends.

During the course self-knowledge tests were also studied. On their basis students could identify their personality traits in order to determine their team role. Due to the fact that students united in groups by themselves, we told them how to form teams beforehand and gave advice to minimize possible conflicts. The experience of many real teams shows that, for example, a small team should not have more than one leader. The main conclusion we wanted to convey to students is that it is important to take into account personal and professional characteristics while forming the team and not to assemble group of friends only.

Also, during the discipline there were business games aimed at working out both general team interaction and group work in IT. Business games simulated requirements analysis processes, design, choosing of architecture, testing, etc. These games made it possible to smoothly enter the team into development process before starting to carry out the main project.

By introducing a single project through the course, students had the opportunity to practice all stages of the project development. Their product went through several cycles from identifying requirements to delivering the product to the customer. Students got real experience by applying the acquired knowledge in practice and could add the project to their CV.

Expectedly, there were certain difficulties that appeared both on the customer side and on the student side. Some students lost their motivation because of lack of interest to the project. At the same time there were customers who ignored their teams or did not paid enough attention to them because of lack of time. But nevertheless, all problems were successfully resolved and all students completed the projects.

In this article we shown the successful experience of implementing the university discipline which guides students through the process of teamwork in the context of IT project development.

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