Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Formation of communication and teamwork skills of future IT-specialists using project technology

To cite this article: M Pavlenko and L Pavlenko 2021 *J. Phys.: Conf. Ser.* **1840** 012031

Formation of communication and teamwork skills of future IT-specialists using project technology

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Abstract. The subject of the study is the formation of communication and teamwork skills of future IT-specialists, using project technology in teaching the administration of computer systems and networks. Content analysis of research has shown that communication and teamwork skills are the most requested and necessary soft skills for future IT professionals. It is offered to use project technology of training for their formation. This technology consists of the approaches and tools application used in real-world software development. To implement this technology, we propose to use mind maps for design. The organization of the working process on the project is implemented in Jira Software, Asana or Trello. Communication among project participants should be implemented with the help of several means: video chats (Zoom, Skype, Google Meet) and written communication in corporate messengers (Slack, Zulip). Experimental verification has shown the efficiency of the proposed design technology implementation.

1. Introduction

Information technologies are evolving rapidly. Computer networks, software, databases play an important role in many areas of modern life: public administration, banking, finance, education, transport, medicine, agriculture, entertainment, law etc. Varieties of computer technologies, their number and volume of implementation are constantly growing. As a result, hundreds of millions of hours of IT work are spent on software development, implementation and maintenance.

Software products are complex systems created by humans. Software by its nature has a number of essential properties (complexity, variability) that make the work of professionals more complicated. Modern software cannot be developed by one person, both small development teams (5-10 people) and large ones, consisting of several hundred developers, can take part in the development. The interaction of specialists in such teams, speed and quality of work are complex processes, which are caused not only by professional practical competencies, but also soft skills.

“Soft skills” are centrally important for human capital development and workforce success. A growing evidence base shows that these qualities rival academic or technical skills in their ability to predict employment and earnings, among other outcomes [17].

Many researchers note that employers are not satisfied with the level of soft skills development of employees. They note that potential employees have lack of or poorly developed competencies necessary for available vacancies. Similar requirements concern the work in the IT field, software development and administration of computer networks and databases [8], [9], [14].

Soft skills include a fairly wide range of competencies. However, today there is no defined list of competencies that should be formed in an IT-specialist. The study by Gerardo Matturro, Florencia Raschetti and Carina Fontán [11] determines that the most important soft skills for the future IT specialist are communication skills, teamwork and analytical skills. Cheryl Aasheim, Jordan Shropshire, Lixin Li and Christopher Kadlec [1] determine that there is a demand at the labor market for IT professionals with such established soft skills as: ethics, professionalism, communication skills, and the ability to work in teams.

The Global Competency Model for Graduate Degree Programs in Information Systems [16] defines the concept of individual foundational competencies. Individual foundational competencies are those competencies necessary for all knowledge professionals in a variety of professions, such as communication, collaboration, and problem solving.

In the process of learning using project technology students gain experience in solving practical problems in future professional activities and learn to organize teamwork. The feature of students' project activities is forecasting its results, analysis and application of necessary informational sources, argumentation of their own judgments and decision-making in nonstandard situations, creating conditions to achieve the goal, presenting results to the audience, self-evaluation and project partners' evaluation [4], [5].

"According to the recent research, project work meets, to some degree, the expectations of its proponents in that the method improves – besides factual learning – the students' motivation, self-confidence, and critical thinking as well as their problem solving, decision making, investigative, collaborative skills. But there is evidence, too, that there exist barriers hindering the achievement of the objectives intended and striven for since neither students nor teachers always fulfill the necessary premises and qualifications completely." [18].

The purpose of the article is to theoretically prove, develop and experimentally test the efficiency of the project technology implementation for the formation of communication and teamwork skills of future IT-specialists.

2. Methods

The following main methods were used in the research process: content analysis of scientific and methodological literature, generalization and systematization to clarify the state of the problem development; survey of applicants for higher education and initial statistical processing of the obtained results to determine the efficiency of project technology implementation for the formation of communication and teamwork skills of future IT-specialists while computer systems and networks administration training.

3. Material

The implementation of the project technology involves the development and presentation of the project on the problems of computer systems and networks administration by students. We propose to link the topics of projects with the problems of implementing a secure network infrastructure of the enterprise, deploying network software, creating cloud services for teamwork and conditions for the through use of corporate network resources in a remote access.

We propose to use cloud computing technologies as the main platform for students to implement network projects.

Cloud computing services are divided into:

- Cloud Software as a Service (SaaS). The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- Cloud Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but

has control over the deployed applications and possibly application hosting environment configurations.

- Cloud Infrastructure as a Service (IaaS). The capability provided to the consumer is to provide processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls) [10].

Cloud Infrastructure as a Service (IaaS) is required for computer systems and network administration projects. For students we offer the following options for IaaS platforms: IBM Cloud, Microsoft Azure, Amazon EC2 and Google Cloud. If the school has a powerful server equipment using private clouds is possible.

During the research a cloud environment built with the application of open-source virtualization management platform Proxmox VE (https://www.proxmox.com/) was used as a platform for students to implement projects. A separate virtual network with a server and client hosts was created for each group of students using KVM hypervisor and LXC containers.

Each project has a corresponding content and structure. The process of project activity fully models the real production process of designing, set-up and implementing network software at the enterprises. The e-portfolio [2] with a set of tasks, developed design solutions, task schedules, etc. is created for each project.

We propose to implement project technology based on an approach founded on the constant teamwork of students applying communication tools used by software developers.

Here is an example of the task: 'Configure the corporate network of the enterprise, providing the required level of security, install and configure services: DNS-server (Bind9), DHCP-server (isc-dhcp-server), remote access server (OpenVPN, OpenSSH), database server (Mariadb), Nginx Web Proxy Server, Apache Web Server, Postfix Email Server and Web Interface, Git-repository Server (GitLab). Configure interaction among installed services.' All tasks have a similar structure and differ with software components.

The first stage includes the division of students into groups of 3-4 participants and roles distribution (project manager, developers and tester). Some roles can be combined. The teacher recommends a list of software for organizing communication in the project, maintaining project documentation, tasks and deadlines tracking and managing.

At the next stage, the groups are given the tasks for network software design, set-up and implementation. Participants discuss the project task in order to identify and structure the components of the project. During the meeting, the group should determine which network tools to use. The group has also to determine the server operating system, routing, security technologies, server solutions for project implementation.

At this stage, we propose to use MindMaping technology [15] to display a complex hierarchy of project tasks and proposed software solutions for each task. As software tools for building a mind map, students are recommended to use the following cloud platforms: GitMind (https://gitmind.com/), MindMeister (https://www.mindmeister.com/), MindMup (https://www.mindmup.com), diagrams.net (https://www.diagrams.net/) and others [6].

The organization of the working process on the project involves tasks' distribution and contractors' appointments as well as determining the timing of project parts fulfillment. Timing, monitoring, testing and project parts control, teamwork management are proposed to be implemented using cloud services Jira Software (https://www.atlassian.com), Asana (https://asana.com/), Trello https://trello.com) and others.

Using teamwork software allows you to create user stories and issues, plan sprints, and distribute tasks among software teams. Prioritize and discuss your team's work in full context with complete visibility.

The student performing the role of the project manager assigns the task in the selected cloud service to each participant and monitors the status of the development process (input tasks, in the process, on the test, ready, etc.).

A high level of communication among project participants is one of the most important factors in the successful project implementation and completion. The purpose of the teacher is to encourage project participants to interact using various means of communication: live discussions at the beginning and at all stages of the project, applying video chats (Zoom, Skype, Google Meet, etc.), written communication using corporate messengers (Slack, Zulip and etc.). The teacher should act as a moderator of student communication, and can also act as a customer of the system being developed.

Project development ends with the presentation of the project by the team of developers. They must demonstrate the design solutions that have been implemented during the work. For this purpose, the presentation demonstrating the work of the developed project is created. Each participant should demonstrate their contribution to the development and describe the difficulties encountered in the process. That is, to share their experience of teamwork and communication in the process of project implementation.

Each project includes the creation of a portfolio that should illustrate all stages of students' group work: mind map, examples of tasks in Trello or Asana and the final project presentation.

4. Results

A pedagogical experiment was conducted to evaluate the efficiency of the project technology implementation for the formation of communication and teamwork skills of future IT-specialists while training of computer systems and networks administration.

The following tasks of the experimental research were defined:

- To determine the parameters of evaluating the efficiency of the formation of communication and teamwork skills of future IT-specialists.
- To evaluate the efficiency of traditional methods of forming communication and teamwork skills of future IT-specialists while teaching the administration of computer systems and networks.
- To evaluate the effectiveness of the developed approaches to the formation of communication and teamwork skills of future IT-specialists while teaching the administration of computer systems and networks.
- To carry out a comparative analysis of the obtained experimental results with the purpose of identifying the efficiency of the study.

During the pedagogical experiment a formative experiment was conducted.

The organization of the educational process in the control group was carried out according to the traditional system of education. This system consists of the application of similar tasks same as in the experimental group, but each student performed the task by himself and the design technology was not used.

The training in the experimental group was carried out using project technology in the training of computer systems and networks. It has been proposed and discussed above.

Upon completion of the molding experiment, a comparative experiment was performed. It provided the analysis of the obtained experimental results; mathematical and statistical processing of experimental results; generalization and analytical presentation of the obtained results and conclusions.

The experimental study was carried out in a real time learning process in order to ensure the reliability of the experimental data. The conditions of the study in the control and experimental groups were the same. Berdyansk State Pedagogical University was chosen as the experimental base. The experiment involved students studying the specialty 015 Vocational Education (Computer Technology) and the sample size was 46 people.

To achieve the validity of the obtained experimental results, all the main influencing factors (student contingent, level of training, conditions of organization and conducting of experimental pedagogical research) in the control and experimental groups were the same, except using the developed design technology for training in the experimental group.

In order to achieve reliability, possibility and validity of the results, the groups were chosen with a random selection (randomization) of study groups, as well as with the mandatory input and output control in the control and experimental groups.

The experiment plan provided the application of the same tasks in the control and experimental groups.

The level of communication skills formation was studied using a standardized method for determining the level of communication proposed by V. F. Riakhovskii [7]. The following scale was used for this technique: very low sociability (25-32), low sociability (17-24), medium sociability (9-16) and high sociability (0-8).

The level of teamwork skills formation was studied using the standardized research methodology “Acceptance of Others Scale” proposed by William F. Fey [13]. The following scale was used for this technique: low level (18-30), medium level with a trend to the low (31-40), medium level with a trend to the high (45-59) and high level (60-90).

A specialized program was used for automation the students’ survey [13]. The programming language R [12] was used for data analysis and diagrams construction.

We will carry out statistical processing of the received data. The analysis of the results provided the division of the results of the sample diagnosis into frequency intervals in accordance with the values provided in the standardized methods.

Input control showed almost the same level of communication skills and teamwork skills for the control and experimental groups, as shown in tables 1 and 2.

Table 1. Comparative analysis of the communication skills formation level in the control and experimental groups (input control).

Level of formation	Control group, number of students (%)	Experimental group, number of students (%)
Very Low (25-32)	40.91	41.67
Low (17-24)	36.36	37.50
Average (9-16)	13.64	12.50
High (0-8)	9.09	8.33

Table 2. Comparative analysis of the teamwork skills formation level in the control and experimental groups (input control).

Level of formation	Control group, number of students (%)	Experimental group, number of students (%)
Low (18-30)	27.27	29.17
Average level with a trend to the low (31-40)	54.55	54.17
Average level with a trend to the high (45-59)	13.64	8.33
High level (60-90)	4.55	8.33

In accordance with the experimental plan, the homogeneity of the experimental and control groups was checked. To analyze the homogeneity of the experimental data, the hypotheses about the equality of the average values were tested by Student’s t-test.

The results of the statistical analysis have shown the equality of the average values of communication and teamwork skills for the control and experimental groups (tables 3, 4). The critical value of Student’s t-test for our sample equals to 2.015 at a significance level of 0.05.

Table 3. Checking the equality of the average values of the communication skills formation level (input control).

Groups	Number of students	Average	Variance
Control	22	22.32	57.75
Experimental	24	20.045	58.99

The calculated value of the Student's t-test equals to 0.073. The critical value of Student's t-test is greater than the experimental one, so, the hypothesis of the average values equality of the communication skills formation level in the control and experimental groups has been confirmed at the level of significance of 0.05.

Table 4. Checking the equality of the average values of the communication skills formation level (input control).

Groups	Number of students	Average	Variance
Control	22	36.32	135.66
Experimental	24	37.38	87.134

The calculated value of the Student's t-test equals to 1.472. The critical value of Student's t-test is greater than the experimental one, so, the hypothesis of the average values equality of the teamwork skills formation level in the control and experimental groups has been confirmed at the significance level of 0.05.

The obtained results of the input control of the forming experiment have confirmed the representativeness and homogeneity of the samples, which allows us to proceed to the comparative stage of the experimental research.

After using the design technology to form communication and teamwork skills, the initial diagnostics was performed for the control and experimental groups. Generalized data on the level of students' communication skills formation after the study are given in table 5, and teamwork skills in table 4 accordingly.

Table 5. Comparative analysis of the communication skills formation level in the control and experimental groups (initial control).

Level of formation	Control group, number of students (%)	Experimental group, number of students (%)
Very low (25-32)	36.36	29.17
Low (17-24)	36.36	37.50
Average (9-16)	18.18	20.83
High (0-8)	9.09	12.50

The corresponding diagram is shown in figure 1.

The level of communication skills formation in the experimental group compared to the control (table 6) increased by 14.39%. The corresponding diagram is shown in figure 2.

The level of teamwork skills formation in the experimental group compared to the control increased by 20.45%.

Statistical analysis of the results of the initial control was performed using Student's t-test to check the hypothesis of average values equality (tables 7, 8). The critical value of Student's t-test for our sample for the results of the initial control equals to 2.015 at a significance level of 0.05.

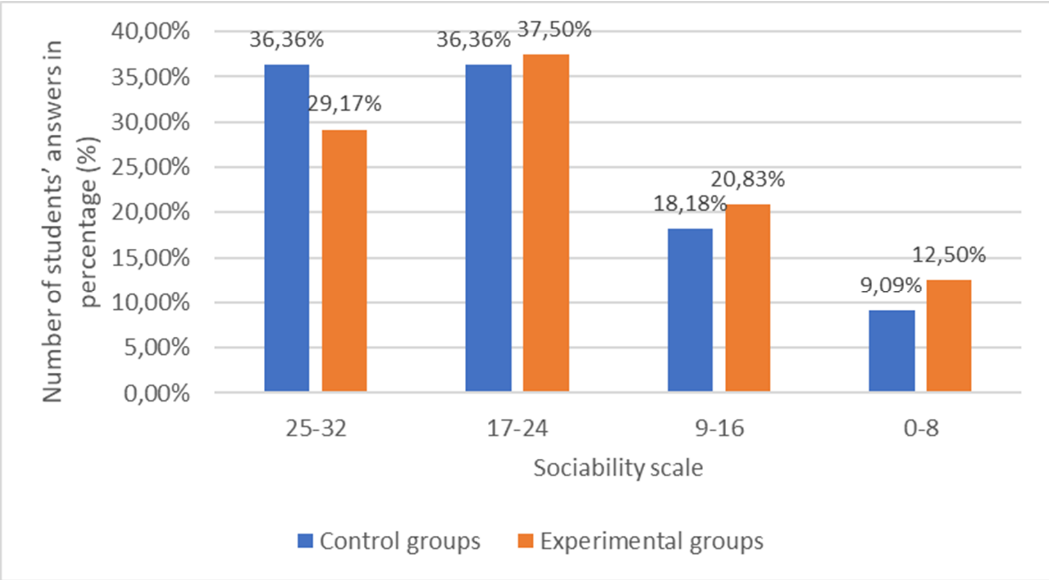

Figure 1. Diagram of the communication skills formation level in the control and experimental groups at the end of the experiment.

Table 6. Comparative analysis of the teamwork skills formation level in the control and experimental groups (initial control).

Level of formation	Control group, number of students (%)	Experimental group, number of students (%)
Low level (18-30)	22.73	20.83
Average level with a trend to the low (31-40)	50.00	41.67
Average level with a trend to the high (45-59)	18.18	20.83
high level (60-90)	9.09	16.67

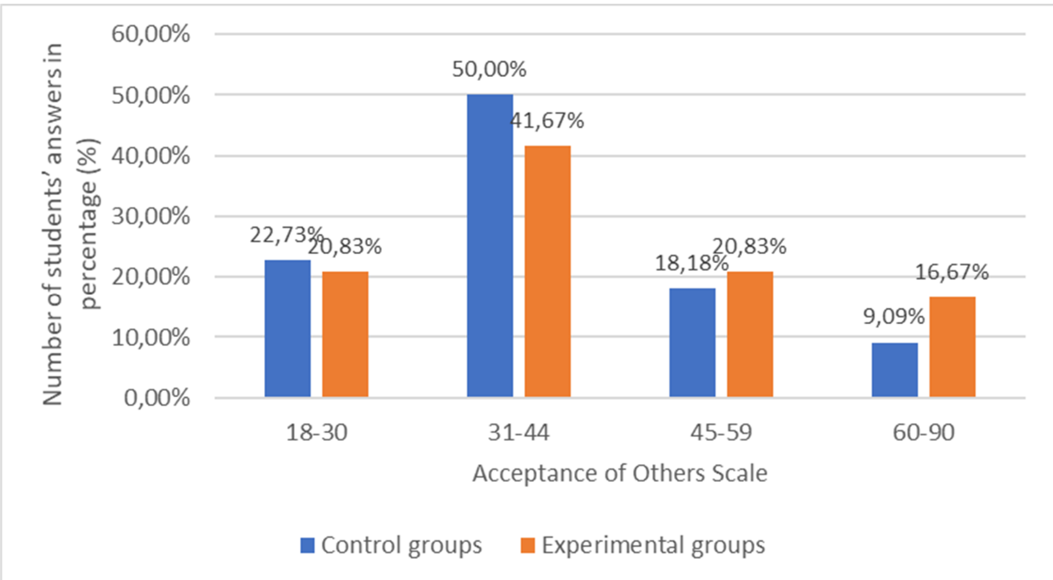

Figure 2. Diagram of the teamwork skills formation level in the control and experimental groups at the end of the experiment.

Table 7. Checking the average values equality of the communication skills formation level (initial control).

Groups	Number of students	Average	Variance
Control	22	20.36	38.528
Experimental	24	17.32	77.656

The calculated value of the Student'st-test equals to 2.158. The critical value of Student'st-test is less than the experimental one, so, the average values of the level of communication skills in the control and experimental groups differ in a significant way (significance level 0.05).

Table 8. Checking the average values equality of the teamwork skills formation level (initial control).

Groups	Number of students	Average	Variance
Control	22	40.09	118.658
Experimental	24	40.41	317.681

The calculated value of Student's t-test equals to 2.796. The critical value of Student's t-test is greater than the experimental one, so, the average values of the level of communication skills in the control and experimental groups differ in a significant way (significance level 0.05).

Thus, the conducted experimental research confirmed the efficiency of using design technology for the formation of communication and teamwork skills of future IT-specialists while the training of computer systems and networks administration.

5. Conclusions

During the research the efficiency of the project technology implementation for the formation of communication and teamwork skills of future IT-specialists in the training of computer systems and networks administration has been theoretically substantiated, developed and experimentally tested.

During the study it was defined that communication and teamwork skills are one of the main soft skills for future IT professionals. Their formation is a necessary and important stage of the professional training.

The proposed approach to using project technology for the formation of communication and teamwork skills of future IT-specialists is based on the application of professionally-oriented tasks with the help of technologies and tools of group work in software development used in real production.

In further research we plan to explore the possibility of project technology application to form a number of other soft skills.

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