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DEVELOPMENT OF SOFT SKILLS IN COMPUTER SCIENCE BACHELORS IN THE PROJECT LEARNING PROCESS

Abstract. The article proposes and substantiates a method of development of soft skills in Computer Science bachelors using project-based learning technologies, as successful employment of graduates in the IT industry market depends on the level of such skills. Developed communication skills, teamwork, and the ability to plan work on a project are important requirements for university graduates' successful employment in the IT industry. The formation and development of soft skills enables the students not only to meet the requirements of the labor market, but also to more successfully develop professional skills (hard skills). The authors propose indicators of soft skill formation by 5 categories: personal effectiveness, communicative, managerial, strategic and information management skills. The methodology of soft skill development for future specialists in information technologies is based on three stages, each of which involves the implementation of different types of projects: collective, term paper and interdisciplinary. The components of soft skills that are formed during each of the stages are determined. The research substantiates the integration of two learning technologies for the implementation of the proposed methodology – blended and project-based learning, which involve the use of digital technologies. During the experimental research, students independently assessed the level of their soft skill formation according to the defined indicators in line with the proposed categories on a 10-point scale. The results of the conducted experimental study proved the improvement of the level of soft skill formation in Computer Science Bachelors in the process of project training. The statistical analysis of the results of the experiment proved the significance of the proposed method and made it possible to confirm its effectiveness.

Keywords: soft skills; computer science bachelors; project-based learning.

1. INTRODUCTION

The problem statement. Training a specialist of a new format, who is successful and competent, is entrusted to universities where the integration of technological innovations, cloud resources and services and methods of project learning can provide a new quality of the educational processes, the results of training and development of soft skills. In the modern world special importance is given to so-called soft skills – “flexible skills.” Some of these skills include: English language proficiency, as foreign communication skills are required in customer relations and communication with an international development team; team skills in project execution; effective communication skills throughout project execution, starting from the first communication with the customer to presentation of ready-made solution skills.

The Forbes Coaching Council also considers soft skills to be meaningful and notes that these skills cannot be taught – individuals must be willing to learn and acquire them through their own experience: to communicate in a constructive way, through their own experience of difficult working situations; to be able to listen – through many working meetings where an active hearing is essential; to be able to conduct complex negotiations – after dozens of difficult dialogues on understanding in various projects [1].

The World Economic Forum named integrated problem-solving skills, critical thinking and creativity among the top 10 skills which will continue to be in demand. The main groups of skills that employers believe will be in demand by 2025 are: critical thinking and analysis, problem-solving, self-management, working with people, management and communication of activities, technology use and development, core literacies, physical abilities. While there is a wide-ranging consensus that no single skill set or area of expertise is likely to be able to sustain a long-term career in the future, the core soft skills of the 21st century – including not just creativity and flexibility but also complex problem solving, critical thinking, and collaboration – will be crucial for enabling people to become better able to adapt to the changing needs of the job market [2].

Future IT specialists need to acquire the above-mentioned personal skills from the university level for a successful career, but traditional methods and forms of organization of work in higher education institutions (HEIs) do not contribute to the development of these skills. A Carnegie Mellon Foundation study found that 75% of long-term job success depends on the level of soft skills employees had. Another LinkedIn study found that 57% of employers value soft skills more than hard skills when making new hires [3].

Analysis of recent studies and publications. The need for qualified specialists in the field of information technologies is constantly growing, both for existing specialties and for new ones in the field of high technologies, training for which must be introduced in higher education institutions. For such specialists, it is important to have the ability to work in a team, therefore, it is recommended to use the project methodology during the training of future IT specialists. Therefore, a successful IT specialist needs to constantly improve their knowledge, skills and abilities, including soft skills, to be in demand in this job market. O. Hazzan and G. Har-Shai [3] argue that people involved in software development processes deserve more attention, and therefore their “soft skills” should also be developed, beyond their scientific and professional skills. P. Moss and C. Tilly [4] define “soft skills” as abilities and traits that relate to a person, their attitude, behavior, and not formal or technical knowledge.

S. Burbekova [5] notes that in order for an IT specialist to meet the demands of the job market, they need to work on developing soft skills such as communication skills, team building and leadership. Soft skills such as leadership, communication, negotiation, problem solving, and team spirit are important for any software development process, as they play a

crucial role and influence how a person performs tasks, so they must be taken into account when designing academic curriculum [6].

Another learning activity outside college is internship/work practices or Industrial Field Experience (IFE), which greatly affects students' soft skills [7]. After the expert validation process, only seven elements were accepted to be the subconstructs for measuring soft skills among Construction Technology students, namely, communication skills, critical thinking, problem solving skills, teamwork, ethics, professional moral and leadership skills [8]. Modern programming is collective, and the usefulness of an individual IT specialist is closely related to their usefulness for the entire team, therefore it requires teamwork, leadership skills, certain knowledge of psychology and management [9].

R. Lavi, M. Tal, Y. Dori [10] in their study identify 14 skills needed by specialists in the 21st century, such as the ability to learn individually, the ability to solve problems, critical thinking skills, the ability to think systematically, skills of experimentation and testing, ability to cooperate, skills of written, oral and intercultural communication and others. In their work, researchers propose to form these skills using active learning methods, in particular, the method of project-based learning, which focuses on interaction and solving real problems.

The research goal. Given this, the purpose of the article is to feature a methodology developed for the formation of soft skills in computer science bachelors in the process of project training and verify it experimentally.

2. RESEARCH FINDINGS

In modern conditions, a competitive IT specialist must have both professional skills and soft skills, that's why they should be viewed as expected results (learning objectives) in the process of training future IT specialists. Today's employers in the IT industry expect a candidate to have dozens of different skills: the ability to think creatively and manage time, communication skills, networking, project management, effective teamwork. The researchers [11], [12] identify the following skills: personal effectiveness, management and strategic skills, information management skills and critical thinking. After analyzing the above classifications of soft skills, 5 categories of skills were formed, which are the most important for the future successful career of IT graduates. The first category includes communication skills. These include: the ability to work in a team, negotiation, the ability to communicate effectively using various tools (within the team, customers, managers), interpersonal communication, the ability to persuade, resolve conflicts, make group decisions, and give presentations. Communication skills are extremely important for a successful IT specialist, as software development teams can work remotely. Thus, the effectiveness of project work largely depends on the ability to communicate with each other, on the knowledge of foreign languages, business correspondence, conflict resolution, group decision making. Another part of the application of communication skills is related to working with clients, namely: active listening, the ability to ask questions correctly, to speak concisely, the ability to work with objections are components of effective communication. The second category includes personal performance skills, which include time management competences, responsibility, resilience, goal achievement, creativity and analytical thinking. To be successful in IT business, it is extremely important to be proactive and innovative, to constantly self-improve, as IT professionals increasingly prefer interesting projects, new technologies and enterprises with a transparent system of work organization. The third category consists of management skills, which include: competences in teamwork, the ability to form and unite a team, to establish a system of communication between its members, the ability to motivate team members, to show leadership qualities. These are the competencies that are necessary for successful work as part of a software development team.

To conduct IT business, it is necessary to develop strategic skills among IT students. These skills are in the fourth category and include strategic decision-making competence, which is very important when using the cutting-edge technology; the ability to operate in a risky environment; to plan students' activities and those of the development team; the ability to delegate authority. Critical thinking is one of the skills of the twenty-first century and one of the necessary skills for effective information management in the field of IT. The future IT specialist needs to be able to analyze, synthesize, evaluate data and messages, make decisions – the competence of the fifth group in the developed classification.

Table 1 presents the classification of soft skills that need to be developed in the process of training future specialists in information technology to ensure their further development and successful employment in the relevant field.

It is possible to develop professional skills and soft skills in future IT specialists by organizing training activities using blended learning technology, which is to mix methods and forms of organizing training activities using information and communication technologies (ICT), project training and teamwork on the project.

Table 1

Required soft skills of IT students

Competence	Indicator
Personal effectiveness (PE)	
PE1. Ability to set a goal and achieve a goal	the student is able to determine the purpose of the proposed project and ultimately achieve the goal by working on the project in a team
PE2. Ability to correctly prioritize tasks within a limited time, rationally calculate time	the student can independently divide objectives into tasks, determine the importance of each of them, effectively allocate time for their implementation
PE3. Ability to maintain a holistic emotional attitude towards yourself and your team	the student is able to control their own emotions and respond to the emotions of others, cope with stressful situations
PE4. Ability to be responsible to the team when working on the project	the student understands their role in the team, is able to assess the impact of their contribution to the overall result of the team
PE5. Ability to interact creatively in a team	the student is able to quickly and efficiently find non-obvious successful solutions to problems, challenges and tasks identified for project work
PE6. Ability to visualize, formulate, solve problem situations, making the right decisions, taking into account the available information	the student can analyze the problem situation, find its solution taking into account the necessary information, choose tools for its visualization
PE7. Ability to present the project to investors or your own team	the student is able to independently develop the structure of the presentation, convey their idea to the audience and the target audience
Communication skills (C)	
C1. Ability to cooperate with colleagues and perform tasks independently	the student is able to effectively manage time to perform tasks, understands their role in the team
C2. Understanding the role and place of strategic communications in the team management system	the student has the tools of dialogue and mediation to establish effective teamwork
C3. Ability to clearly articulate needs, expectations of the team and the environment	the student forms their own style of teamwork by using their strengths
C4. Ability to analyze and resolve conflict situations in terms of team positions and interests	the student is able to identify and assess the conflict situation in the work of the team, to find its solution that will contribute to its further effective work

C5. Ability to negotiate, possess the algorithm of how to avoid mistakes	the student is able to avoid communicatively incorrect actions and expressions
C6. The ability to persuade others to accept their philosophy and way of thinking	the student can argue his point of view and influence communicative partners
C7. Ability to make group decisions	the student is able to influence people and be convincing, listen to the colleagues' point of view, respect their opinion
Managerial skills (M)	
M1. Ability to unite a group and build effective teamwork to solve specific tasks	the student can form a favorable climate in the team, find common features in team members to improve interaction between them
M2. Ability to organize joint activities and form a viable team	the student is able to assess the atmosphere in the team, distribute roles and tasks among team members
M3. Ability to form a team communication system using appropriate cloud services	the student can independently evaluate and select tools for the formation of a communication system in the team, integrate them
M4. Ability to motivate all team members to actively work to meet their needs and to achieve project goals	the student can independently determine what needs motivate other participants to work and direct them to achieve project goals
M5. Ability to take control of the situation	the student can independently evaluate mistakes in the work of the team, find ways to solve them
M6. Ability to influence the team with regard to the role in the project or through their abilities, skills or other resources	regardless of their role in the team, the student can show their leadership qualities, convey their point of view and convince others of it
Strategic skills (S)	
S1. Ability to plan long-term based on intermediate project objectives	the student can independently define the goals of the project, plan the execution of the task in such a way that they can be achieved in the shortest possible time
S2. Willingness to make strategic decisions	the student independently makes decisions when working on the project, offers options for solving problem situations
S3. Ability to work in conditions of risk	the student can independently assess risks, find ways to minimize them
S4. Willingness to delegate authority to other team members	the student can distribute tasks among team members and work together on their performance
Information management skills (IM)	
IM1. Ability to quickly identify important and minor tasks, to deal more effectively with problems, and to deal with different tasks in a more efficient and effective manner	the student has no difficulty in filtering the results obtained; they can assess the problem and find a solution without the help of the teacher
IM2. Ability to search, process and create information, as well as critically interpret the data obtained	the student can formulate a search request, select the relevant data, and assess the validity and integrity of the received data
IM3. Ability to target and organize data	the student is able to independently determine the purpose in finding the necessary information
IM4. Readiness to evaluate the message	the student can assess the importance and urgency of the messages received from both the teacher and team members
IM5. Ability to make decisions according to the situation, to make the choice that suits you best	it is not difficult for the student to assess the situation and the conditions for achieving the objectives and, on the basis of the evaluation, to find the most effective solution
IM6. Ability to build your own learning trajectory, determine the goals of new knowledge and ways to achieve them	the student seeks to acquire new knowledge, skills and abilities

The basic learning technologies that ensure the effective development of soft skills are project and blended learning. The combination of these technologies makes it possible to apply the project method in a mixed format using digital technologies. The project method provides the focus of learning on students' independent activities; its application promotes the development of critical thinking, personal skills, ability to apply knowledge to solve problems from project implementation to self-control and self-assessment, navigate in the information space. In blended learning, it is important to use various forms of organization of the educational process, including: group work, which is carried out by uniting students in groups to perform certain tasks; individual work, which is carried out by creating the necessary conditions for the identification and development of individual characteristics of the student in the learning process on the basis of personal-activity approach.

Figure 1 shows the structure of the methodology for the formation of soft skills in future IT specialists in three stages: (1) collective, (2) term paper, (3) interdisciplinary. For each stage, cloud services are defined to work on the project task. In particular, Microsoft SharePoint service was tested for joint work on the team development project of the first stage, GitHub was offered for collective development of term papers in disciplines in the second stage, Jira project management service was used in the third stage during interdisciplinary project implementation.

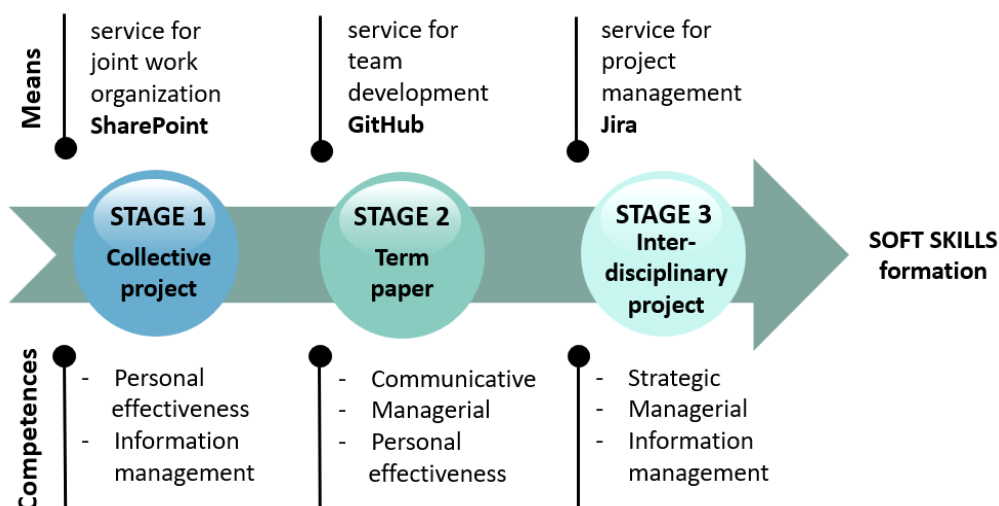


Figure 1. The structure of the methodology of soft skills formation in future IT specialists

Examples of training projects for IT specialists are given in Table 2. For each stage, the objective of the project work on the formation of the constituents of the soft skills is defined.

Table 2

Class projects in the process of training IT specialists

Academic discipline	The purpose of the project	Project content	Stage/ Academic term
Information technologies	to form students' skills of personal effectiveness (PE1, PE3, PE4, PE6) and information management (IM1-IM4)	acquaintance with IT students' opportunities, modern needs in the labor market; formation of the student educational environment; building the IT student trajectory	1/2

Project type: collective project			
Means: Microsoft SharePoint			
Competences: personal effectiveness, information management			
Object-oriented programming, Organization of databases	to form students' communication skills (C1-C7), managerial (M1-M2) and personal effectiveness skills (PE2, PE5, PE7)	designing a relational database model for the future automated system; building class diagrams and developing a system using class composition	2/4
Project type: term paper			
Means: GitHub			
Competences: communicative, managerial, personal effectiveness			
System analysis, Computer networks, Web technologies and web design, Economics and business	to form students' strategic (S1-S4), managerial skills (M3-M6) and information management skills (IM5-IM6)	development of a project to start your own IT business, namely: analysis of the IT services market; implementation of structural-functional and object-oriented analysis of the subject area; business process modeling; designing a computer network of the company's office and selecting the necessary equipment; creating a website to promote the company's activities; creation of the company's business plan; calculation of project payback and design of company development strategies	3/4
Project type: interdisciplinary project			
Means: Jira			
Competences: strategic, managerial, information management			

3. THE RESULTS AND DISCUSSION

The pedagogical experiment on the development of soft skills in computer science bachelors lasted for 3 years (115 students in the experimental and 109 in the control groups). In the control group, the curriculum provides only for the implementation of term projects in certain disciplines on the implementation of which students work individually. Each term, students of experimental groups were offered project tasks, both group and individual, which were performed either while studying the academic disciplines, or were interdisciplinary projects. The course of experimental research included the measurement of soft skills in first-year students at the beginning of university studies and at the end of each year after the completion of the educational project. According to the defined indicators (Table 1), students independently assessed the level of their soft skills formation in 5 categories on a 10-point scale. The level of formation of each category of skills was determined as the average value of the assessment for each indicator.

During the implementation of project tasks in Stage 1, students performed a collective project based on the SharePoint service Microsoft 365, which was offered to 1-st year students as part of the course in Information Technology. The purpose of organizing such project group work was to form students' competences of communication and management blocks. The content of the "Education of a modern IT specialist" project was to get acquainted with the opportunities of IT students, modern needs in the labor market; formation of the student's personal educational environment; building the trajectory of the IT student. The choice of the project topic was aimed at increasing students' motivation to study in the chosen field, to promote conscious professional orientation and increase responsibility for the results of their own learning and professional growth.

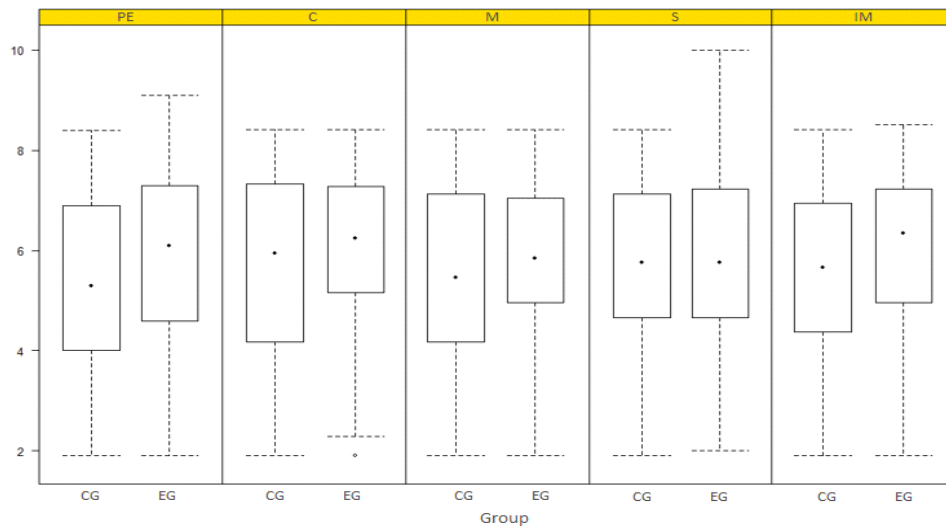


Figure 2. Soft skills assessment after Stage 1

In the course of such collective projects, the first stage achieved an improvement in the students' personal skills, in particular: time management (by almost 11 percent), leadership skills (by 8 percent), patience and the ability to listen to other points of view (by 2 percent). Summary results of the soft skills assessment for each category in the control and experimental groups after the first year of studies are presented in Figure 2.

During Stage 2, students were offered mini-projects, group and individual project assignments, term papers within the framework of academic disciplines. When studying the disciplines "Object-oriented programming" and "Database organization" students were asked to execute a mini-project using a cloud service for the collective development of GitHub software products. The aim of such projects was to develop personal efficiency skills among future information technology specialists. The purpose of this mini-project was to design a relational database model for a future automated system (according to the theme chosen by the students); to construct a class diagram and to develop a system using the composition of classes.

As a result of such a mini-project, students increased the level of their soft skills, personal efficiency in particular, by 10.4% and communication skills by 8.17%.

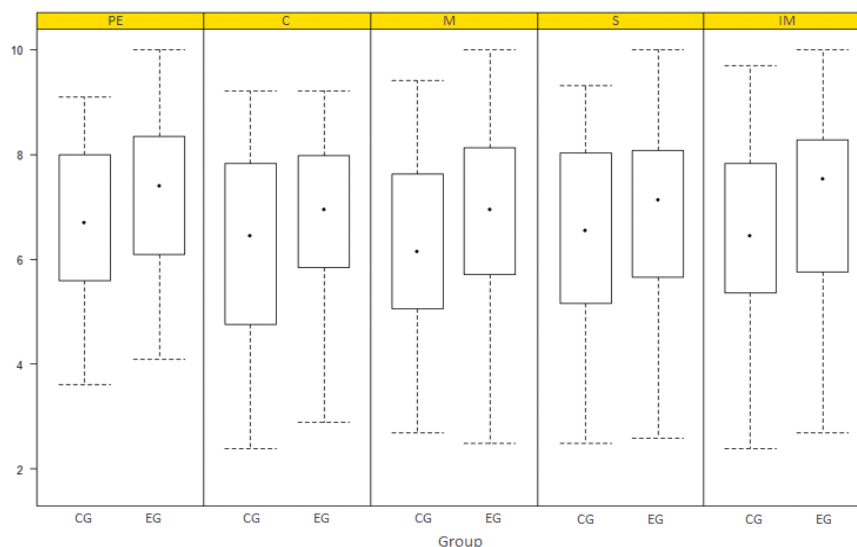


Figure 3. Soft skills assessment after Stage 2

Summary results of the soft skills assessment for each of the categories in the control and experimental groups after Stage 2 are presented in Figure 3.

In Stage 3, during an interdisciplinary project, students worked on a collective case study using the Jira cloud service, which combined tasks from 4 disciplines: Systems Analysis, Computer Networking, Web Technologies and Web Design, Economics and Business. The purpose of organizing such an interdisciplinary project was to develop students' skills of strategic management, personal effectiveness and information management. The students were given a task to develop a project to start their own IT business, namely: to analyze the IT services market; to implement structural-functional and object-oriented analysis of the subject area; to carry out business process modeling; to design a computer network of the company's office and to choose the necessary equipment; to create a website to promote the company's activities; to create the company's business plan; to calculate project payback and development of company development strategies.

In assessing the rise of soft skills in the execution of an interdisciplinary project, students noted an increase in skills, namely: strategic management (growth by 13%); personal efficiency (almost 8%); and information management (increase by 10.2%). Summary results of the soft skills assessment for each of the categories in the control and experimental groups after the third year are presented in Figure 4.

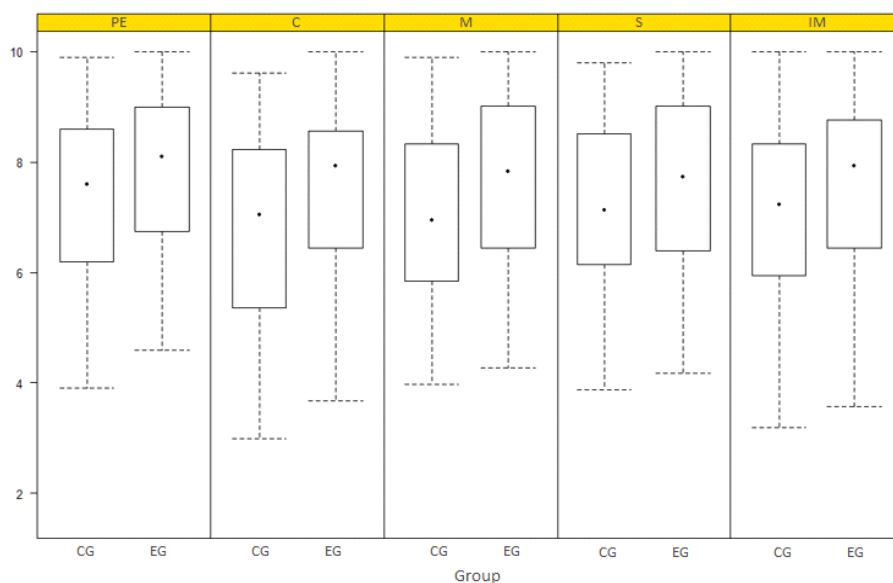


Figure 4. Soft skills assessment after Stage 3

To assess the results of soft skills development, the level of formation of each component of soft skills in the control and experimental group was compared based on the results of each project. The results of the experiment on the formation of strategic skills in the control and experimental groups on the results of each project are presented in Table 3.

Table 3

Assessment of strategic skills

Stage	Group		Overall	Difference
	Experimental	Control		
Stage 1	5.84	5.68	5.76	0.16
Stage 2	6.80	6.52	6.66	0.29
Stage 3	7.56	7.15	7.36	0.41
Total	6.73	6.45	6.59	0.28

Stage 2 - Stage 1	0.96	0.84	0.90
Stage 3 - Stage 2	0.75	0.64	0.70
Stage 3 - Stage 1	1.72	1.48	1.60

While assessing the aggregate of strategic skills (Figure 5), we observe a significant increase in the difference in the assessment of strategic skills in a multidisciplinary project.

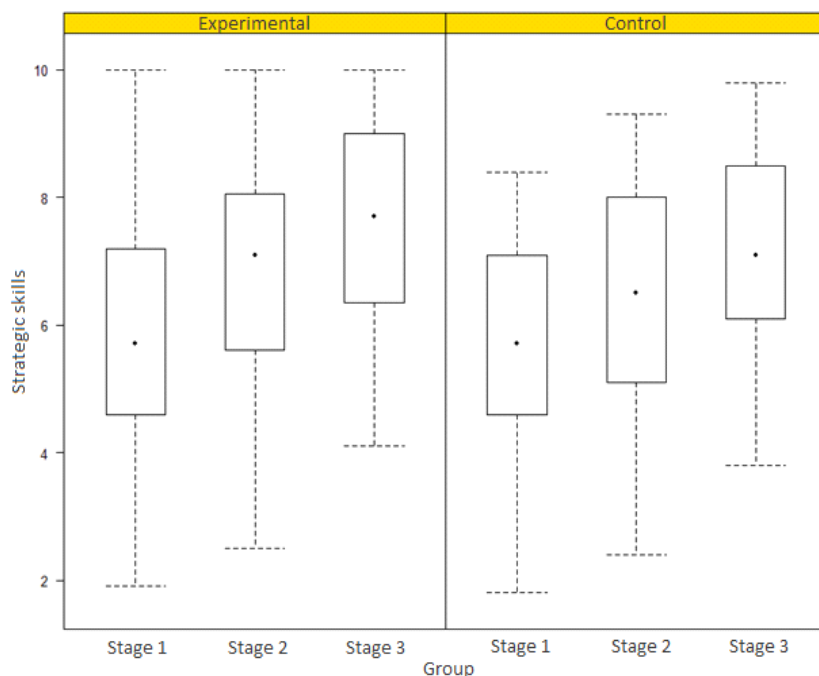


Figure 5. Assessment of strategic skills in control and experimental groups based on the results of three stages

To statistically verify the results obtained, the null hypothesis was put forward that the difference in the average assessment of the level of strategic skills during the implementation of different projects is statistically insignificant. This hypothesis was tested using analysis of variance. The two-factor dispersion model is presented in Figure 6.

```
mod <- aov(strat ~ group*etap + Error(id/etap), data=Data)
##           Df Sum Sq Mean Sq F value Pr(>F)
## group      1   13.6   13.582    4.53  0.0481
## Residuals 222 1675.4    7.547
##           Df Sum Sq Mean Sq F value Pr(>F)
## etap       2  288.64  144.32  370.469 <2e-16 ***
## Residuals 444  172.97    0.39
```

Figure 6. Two-factor variance model

To evaluate the variance model, the value of the Fisher test was found based on the mean squares of the deviations in and between the groups and the corresponding degrees of freedom for each of the factors:

For groups:

$$v_{BG} = m - 1 = 2 - 1 = 1$$

$$v_{WG} = n - m = (109 + 115) - 2 = 222$$

where m – number of factor levels (groups), n – number of observations (students).

Respectively, according to Fisher's criterion tables the theoretical value at a significance level of 0.05 is – $F_{0,05;1;222} = 3,884$.

For each of the projects:

$$\nu_{BG} = (m_1 - 1) * (m_2 - 1) = (2-1) * (3-1) = 2$$

$$\nu_{WG} = (m_1 + m_2 - 1) * (n - 1) = (2+3-1) * ((115+109)/2 - 1) = 4 * 111 = 444$$

where m_1, m_2 – number of levels for intergroup (group) and intragroup (stages) factors, n – the number of observations (students) in each sample divided into groups and educational projects, respectively.

Accordingly, the theoretical value is – $F_{0,05;2;444} = 3.016$.

The results show that there is a statistically significant relationship for groups and training projects, which is indicated by the value of the actual F statistics, which exceeds the critical values found: $4.53 > 3.884$ and $370.469 > 3.016$, consequently, it can be concluded that the difference in the assessment of strategic skills of 0.28 between the control group and the experimental group is statistically significant.

A similar assessment was conducted for other components of IT students' soft skills (Table 4).

Table 4

Statistical evaluation of soft skills components

Soft skills component	Difference as a whole	Assessment for the influence of groups		Assessment for the influence of stages	
		F theoretical	F actual	F theoretical	F actual
Personal effectiveness	0.51	3,884	7.027	3,016	504.410
Communicative skills	0.52		5.944		333.313
Managerial skills	0.49		5.53		322.541
Information management skills	0.60		8.281		357.348

The obtained results show a statistically significant difference in the evaluation of soft skills in students of control and experimental groups for each component, as well as a statistically significant relationship available for groups and stages. Accordingly, the influence of the proposed training technologies on the development of the strategic skills of future information technology specialists has been confirmed.

4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

In the IT-industry market, the possession of soft skills for IT students is a prerequisite for successful employment. Soft skills are highly important in the context of future work in the IT industry and are classified into 5 groups: management, communication, personal effectiveness, strategic management and information management. For each group indicators are defined, according to which the level of formation of the respective skill in the future IT-specialists was determined according to the developed model of formation of soft skills. Development of “soft skills” in future IT specialists at Stage 1 (communication and management skills), Stage 2 (personal effectiveness skills), Stage 3 (strategic management skills, information management skills, personal effectiveness) using cloud-based tools and a project-based learning methodology makes it possible to draw conclusions about the effectiveness of the proposed methodology. During the pedagogical experiment, the level of personal effectiveness increased by 15.3 %, and communicative skills by 16.7%, management skills have increased by 10.7%, strategic skills by 12.3%, information management skills by 10,2%. Thus, the proposed “soft skills” formation method can be applied to the organization of the educational activities of computer science bachelors.

We see the prospect of further research in the study of the impact of blended learning on the development of soft skills of computer science bachelors.

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РОЗВИТОК SOFT SKILLS БАКАЛАВРІВ КОМП'ЮТЕРНИХ НАУК У ПРОЦЕСІ ПРОЄКТНОГО НАВЧАННЯ

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Анотація. У статті запропоновано та обґрунтовано методику розвитку м'яких навичок з використанням технологій проектного навчання для бакалаврів комп'ютерних наук, від рівня сформованості яких залежить успішне працевлаштування випускників на ринку IT-індустрії. Розвинуті комунікативні навички, командна робота та вміння планувати роботу над проектом є важливою вимогою до випускників закладів вищої освіти для майбутнього працевлаштування в IT-галузі. Формування та розвиток soft skills дозволяє не тільки відповідати вимогам ринку праці, а й більш успішно розвивати професійні навички (hard skills). Автори пропонують показники сформованості навичок за 5 категоріями: особистісна ефективність, комунікативні, управлінські, стратегічні та інформаційно-управлінські навички управління інформацією. Методологія розвитку soft skills у майбутніх фахівців з інформаційних технологій базується на трьох етапах, кожен з яких передбачає виконання різних типів проектів: колективних, курсових та міждисциплінарних. Визначено компоненти soft skills, які формуються на кожному з етапів. У дослідженні обґрунтовано інтеграцію двох технологій навчання для реалізації запропонованої методики – змішаного та проектного навчання, що поєднує запропоновані форми та методи навчання з використанням цифрових технологій. Під час експериментального дослідження студенти самостійно оцінювали рівень сформованості soft skills за визначеними показниками відповідно до запропонованих категорій за 10-бальною шкалою. Результати проведеного експериментального дослідження довели підвищення рівня сформованості soft skills у майбутніх бакалаврів інформатики в процесі проектного навчання, проведено статистичний аналіз результатів експерименту та доведено їх значимість, що дозволило підтвердити ефективність запропонованої методики.

Ключові слова: soft skills; бакалавр комп'ютерних наук; проектне навчання.



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