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HYBRID CLOUD-ORIENTED LEARNING ENVIRONMENT FOR IT STUDENT PROJECT TEAMWORK

Abstract. The article proposes a technology for the development and implementation of a hybrid cloud-oriented learning environment for the electronic support of interdisciplinary projects in the educational process of future IT specialists. To organize such a project, a model of hybrid cloud-oriented learning environment was designed. The components of such an environment are as follows: competence, communication and technology. Based on the developed model, a MS Teams-based cloud environment for project teamwork was created. It integrated all the necessary services for the implementation of an interdisciplinary project. The technological component regulates the content, methods and forms of training during the project implementation. According to the content of the interdisciplinary project, methods and forms of training, both traditional and cloud-oriented, were selected. This environment provided interaction between teachers of different disciplines and teams of students. The software component consists of tools for communication, project management and placement of the teaching resources included in MS Teams and complemented by additional tools that integrate with it, for example, professional tools and tools for presenting the results of work. Teachers could additionally integrate necessary e-learning courses and tools. Data analysis of experimental studies demonstrated that MS Teams-based cloud-oriented environment, which ensures execution of tasks on communication, organization of teaching process, project management and makes it possible to integrate additional tools for arranging an interdisciplinary project, namely, professional, educational and the like, – is an effective environment for the development of the digital, professional and personal competences of the future IT specialist. Moreover, interdisciplinary projects contribute to the development of integral competence of future IT specialists. An experimental study conducted on the basis of the National University of Life and Environmental Sciences involved 3rd year students of the specialty 122 – "Computer Science".

Keywords: hybrid cloud-oriented learning environment; project teamwork; IT students; interdisciplinary project; digital competences; professional competences; soft skills.

1. INTRODUCTION

The problem statement. IT industry requires that graduates of IT majors have both professional competence and soft skills. Employers expect that the new generation of IT specialists possess dozens of such skills, including creative thinking, time management, communication and networking skills, project management and effective teamwork.

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If we want our future IT specialists to take leadership positions in their professional activities in this industry and to meet the requirements of customers, it is also necessary to develop the students' ability to solve complex integrated specialized tasks in the process of training, to apply modern methods and technologies for developing IT solutions that provide for team development of an IT project. Therefore, in the process of training future IT specialists, it is necessary to develop an integral competence that includes not only professional competences, but also soft skills. The problem of forming integral competence lies in the fact that a student receives a complex task for the study only when preparing a diploma project. In this study, we will understand integral competence of a future IT specialist as the ability to solve complex specialized problems or do practical tasks in the field of information systems and technologies, characterized by complicated and undefined conditions, using IT theories and methods. The structure of the integral competence of a future IT specialist is understood here as a combination of professional and general competences which gives the possibility to attain such ability [1].

One of the most effective methods of forming integral competence is the student's project activity aimed at solving a complex task. Such complex tasks can be developed in the form of interdisciplinary projects but solved through the use of e-environment for teamwork on the implementation of the project task.

Analysis of the latest research and publications. Project work can become the most applicable teaching method that can enhance language learning when it is combined with constructivist concepts such as inquiry-based learning, cooperative learning and problem based learning [2].

The project activities of future specialists in the field of information technology is one of the components of the educational process, aimed at forming skills for work in the information space, professional self-development, creativity, information culture, self-directed activities focused on improving and systematizing of professionally meaningful knowledge and skills [3]. The teacher and perhaps employers should provide guidance and support, giving the student considerable responsibility in planning, conducting, and evaluating the project [4].

The organization of the group project work of future IT specialists within one discipline was considered in the works [5], [6], [7]. Typically, the project method is applied for teaching an individual discipline in the process of training IT specialists. Realization of project tasks within one discipline limits the use of the project methodology. Integration of several academic disciplines in developing project tasks remains a problem which needs to be addressed to improve the quality of knowledge acquisition both in each discipline and, taken together, to form students' integral competence.

Interdisciplinary projects can become an appropriate learning tool based on competences [1], [9], [10].

It is advisable to organize interdisciplinary projects with the aim of familiarizing students with real processes of software development, as well as encouraging active teamwork, in the process of which they can try different areas of activity in the specialty in order to raise their interest in the IT profession [11].

An interdisciplinary approach combines different scientific fields to solve the problem. Application of the interdisciplinary approach in the process of professional training of future IT-specialists is a part of their professional competence formation [12].

The introduction of interdisciplinary projects is an important component of training students in engineering specialties in modern conditions [13]. The issue of organizing the environment for the students' work is prompted by the necessity to organize students' collaborative work on projects, create conditions for the implementation of the acquired knowledge in practical situations, the development of skills in teamwork and communication.

Studying and substantiating the necessary directions of using ICT in the educational process should be considered as one of the most important pedagogical problems, in particular, in the context of the humanization of education [14].

Within the concept of modernizing current education, the issue of creating a single educational environment on the basis of widespread use of modern high-speed information and communication technologies is the subject of discussion by many scholars, teachers and methodologists. One of the ways of implementing such an educational environment, along with the active development of educational Internet resources and technologies, is the application of cloud technologies in the educational process [15], [16], [17].

The use of cloud technologies in the learning process provides a significant increase in theoretical and practical training of future specialists [18], [19], [20], [21].

The purpose of the article is to design a hybrid cloud-oriented learning environment that will provide the necessary set of resources and services for the implementation of interdisciplinary projects in the educational process of future IT specialists.

2. THE RESULTS AND DISCUSSION

2.1. The model of hybrid cloud-oriented learning environment for executing an interdisciplinary project

The essence of cloud-oriented learning environment and its potential have been the subject of research by V. Bykov [22], S. Lytvinova [23], A. Salam, N. Sardar [24], O. Saad, M. Rana [25]. In our research, we understand hybrid cloud-oriented learning environment as an ICT-environment which functions on the basis of cloud computing technology and combines didactically grounded use of education resources and services of the educational institution academic cloud with generally accessible clouds [26].

The creation and maintenance of an interdisciplinary project implementation environment provides educators with an opportunity to select the means available to them to complete project tasks, integrate the necessary professional tools into the created environment, provide communication between the teaching staff who teach the project discipline and the teams of students. For students there is an opportunity to plan effectively the stages of the project, distribute tasks between team members and control their implementation, organize teamwork to create the final product of the project.

Based on [24], [27], [26], we single out the following structural components of a university hybrid cloud-oriented learning environment which can be used for implementation of interdisciplinary projects: competence component, communicative component and technological component. Their content is presented in Fig. 1.

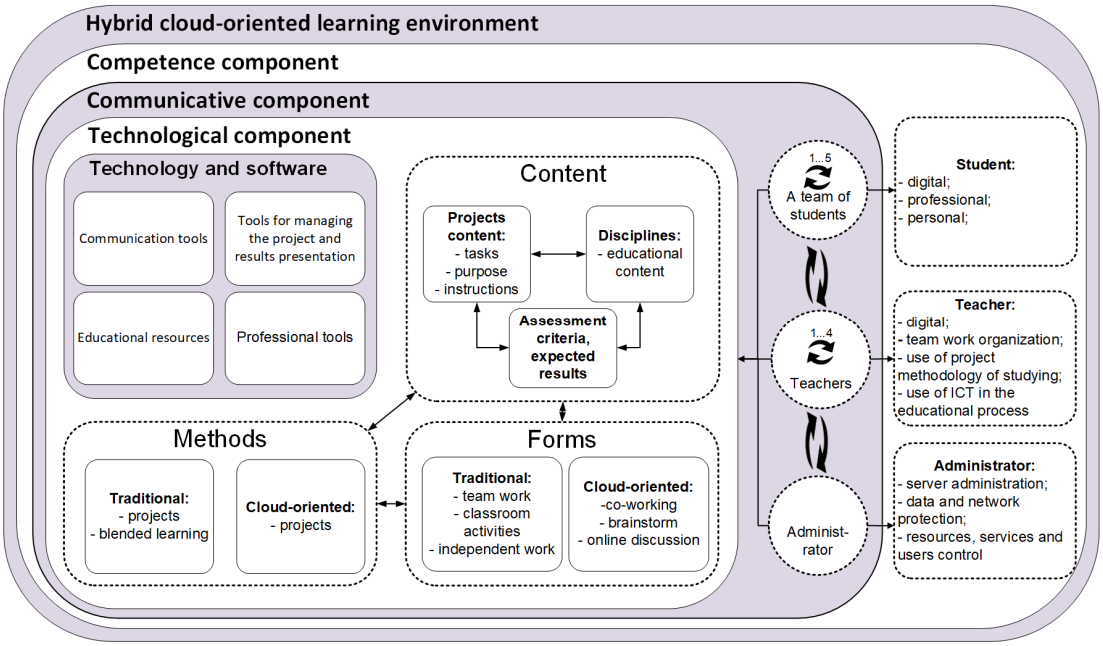

Fig. 1. The hybrid cloud-oriented learning environment for executing an interdisciplinary project

Based on the developed model, a cloud environment for Microsoft Teams-based group projects was created, which integrated all the necessary services for the implementation of an interdisciplinary project. The technology and software components of such an environment are shown in Fig. 2.

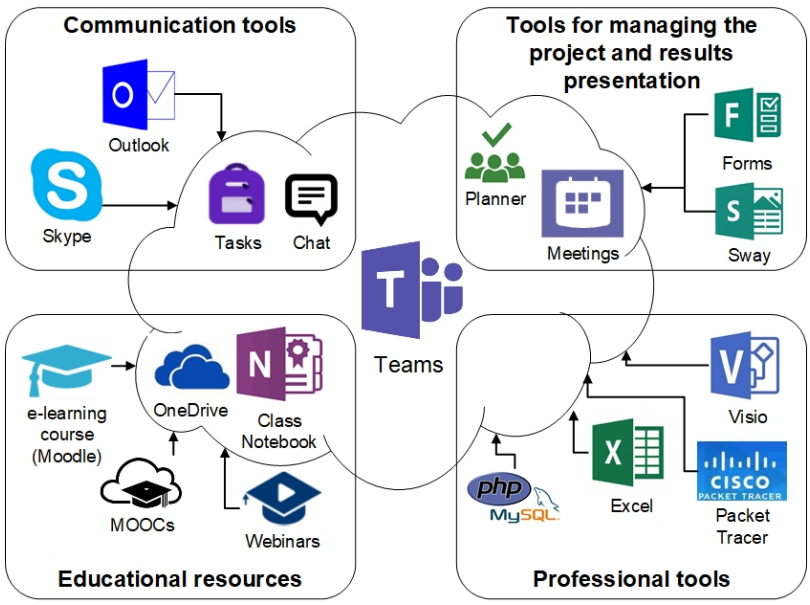

Fig. 2. The technology and software component of the hybrid cloud-oriented learning environment

This environment provided interaction between teachers of different disciplines and teams of students. The software component consists of tools for communication, project management and placement of the teaching resources included in MS Teams and complemented by additional tools that integrate with it. MS Teams created an environment

for each team (Fig. 3), in which students had access to learning resources (Class Notebook, OneDrive) – (1), communication tools (Tasks, Chat) – (2), project management tools (Meetings, Planner) – (3). In addition, the students had an opportunity to integrate additional services and tools into the environment: communication tools (Outlook, Skype), professional tools (Visio, Microsoft Excel, PHP, MySQL, Packet Tracer) and tools for presenting the results of work (Forms, Sway). Teachers could additionally integrate necessary teaching materials (e-learning course, MOOCs, webinars).

2.2. Project implementation: task, tools and examples of teamwork

The use of a hybrid cloud-oriented learning environment for organizing students' work on the implementation of an interdisciplinary project promotes the development of not only professional competences, but also soft skills. This is confirmed by an experimental study conducted on the basis of the National University of Life and Environmental Sciences of Ukraine in the study of such academic disciplines as "System Analysis", "Computer Networks", "Web Applications Development", "Economics and Business" by the 3rd year students of the specialty 122 – "Computer Science".

The technological component regulates the content, methods and forms of training during the project implementation. During the implementation of the interdisciplinary project "Development of a business project of an IT company", all the tools specified in the technology and software components of the hybrid cloud-oriented learning environment were used.

The purpose of this project was to form an integral competence, develop digital, professional, personal competences of the IT students.

The students' task consisted in developing a project of starting their own IT business. The content of the project was: to conduct an analysis of the market of IT services; to implement a structural-and-functional and object-oriented analysis of the subject area; to model the business process; to design a computer network of the company's office and to select the necessary equipment; to put up a website, to promote the company's activities; to create a business plan for the company, to calculate the payback of the project and to elaborate the company's development strategies.

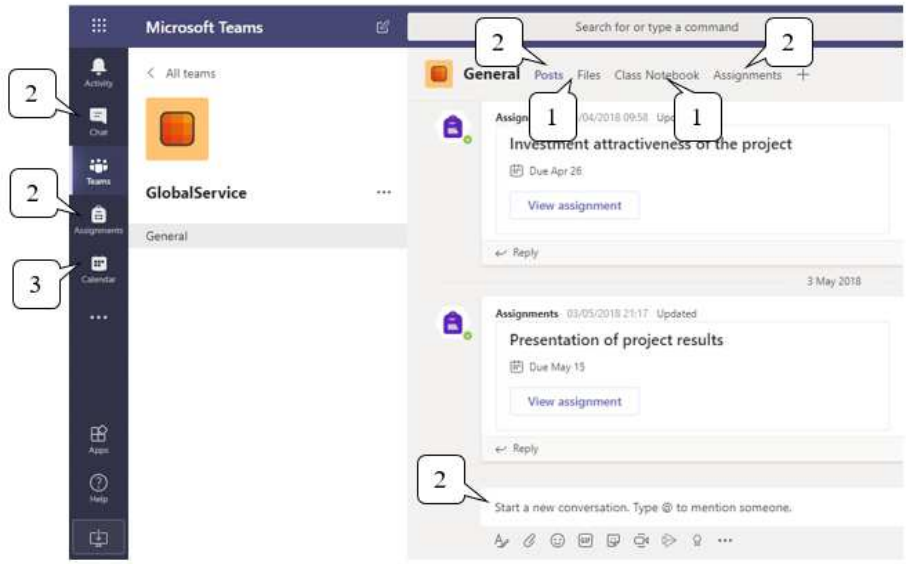

Fig. 3. An example of the environment of a teamwork in MS Teams

Fig. 4 presents the stages of the project implementation, the content of each stage, the assessment criteria and the expected result of the project implementation. In order to complete each task, instructions and the necessary teaching materials were developed as part of the electronic courseware. The professors selected the tools necessary for each stage of the project.

According to the content of the interdisciplinary project, methods and forms of training, both traditional and cloud-oriented ones, were selected. Traditional forms and methods of teaching were used in the study of theoretical material and the implementation of practical work on the subjects involved in the project. In particular, the method of blended learning was applied in order to work out theoretical material using the resources of the e-course during independent work. During the classroom activities, the students worked in teams on the implementation of practical tasks that were part of the project. The cloud-oriented learning methods were used for communication, collaborative work on project tasks in Microsoft Teams and Integrated Outlook and Skype services.

In order to ensure students' work on the implementation of this project, a project schedule was elaborated at the project stage and a project day was selected during which the students performed corresponding assignments. The theoretical material necessary for students to solve the problem was delivered at lectures alternating in each discipline in accordance with the schedule. For example, while completing the tasks of the first stage of the project, the students got acquainted with the theoretical material of the course "System Analysis" for 4 weeks, reinforced the theoretical material learnt using the "Lessons" in the e-learning course, did practical assignments, fulfilled the project's tasks during the project day.

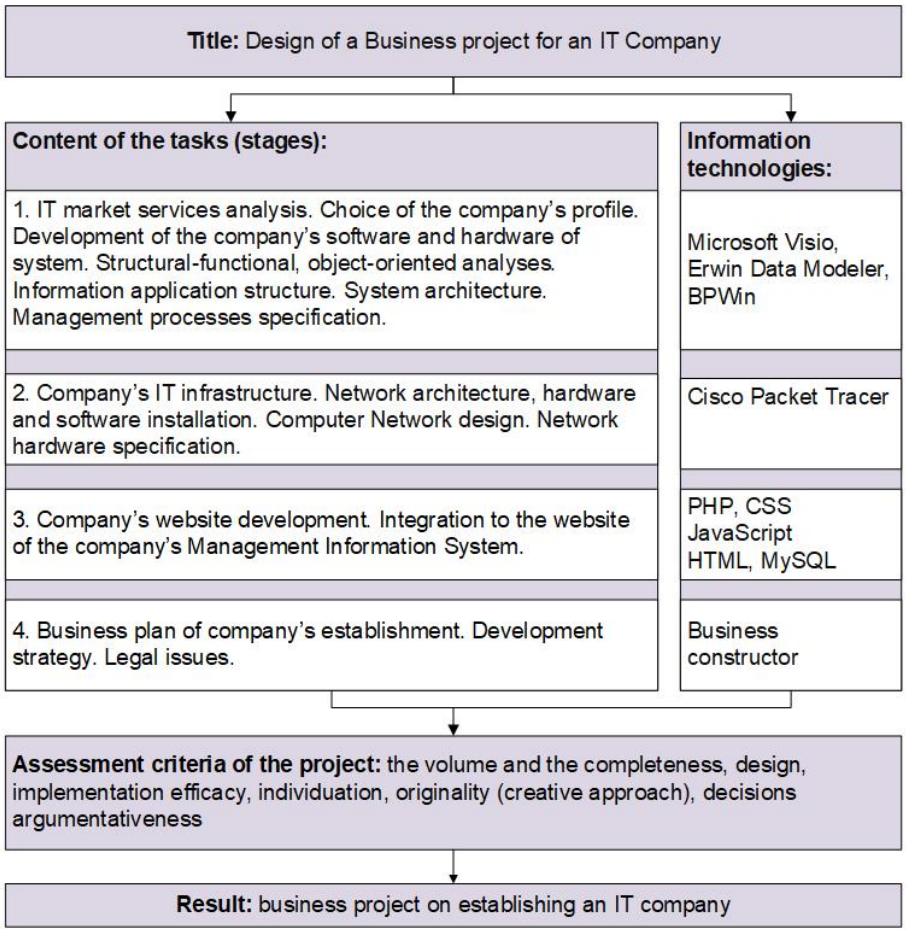

Fig. 4. Stages of implementing an interdisciplinary project "Development of a business project of an IT company"

The teachers used a Task service integrated in the environment to familiarize students with tasks for each project day, terms for their execution, and to provide additional materials and instructions necessary for the execution of tasks (Fig. 5).

In such a manner, we combined the project method and the method of blended learning, when students studied the theoretical material and performed practical assignments on their own and worked on solving project tasks in the classroom.

While working on the project in the cloud-oriented environment, based on Microsoft Teams, it was necessary to provide communication between: teachers; a teacher and a team; students in the team; teachers and administrators.

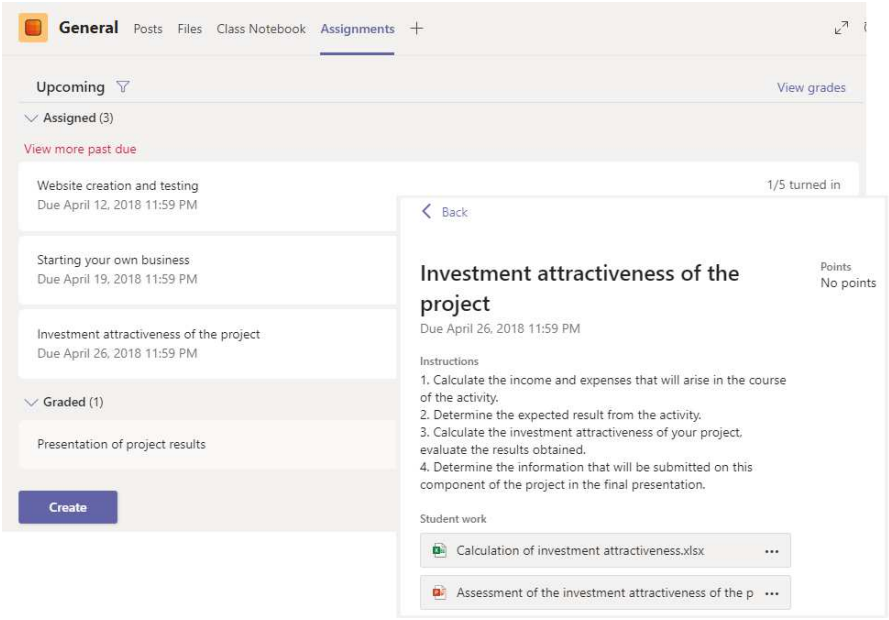

Fig. 5. An example of using the Task service while implementing an interdisciplinary project

Fig. 6 shows some examples of communication implementation: in the Class Notebook class teams received training materials for work (1); they reviewed the criteria for the assessment of each stage of the project (2), the expected result (3), and the timetable (4); team members had a common space for cooperation (5), in which they collectively fulfilled the project's objectives, and each participant had the space for an independent work (6).

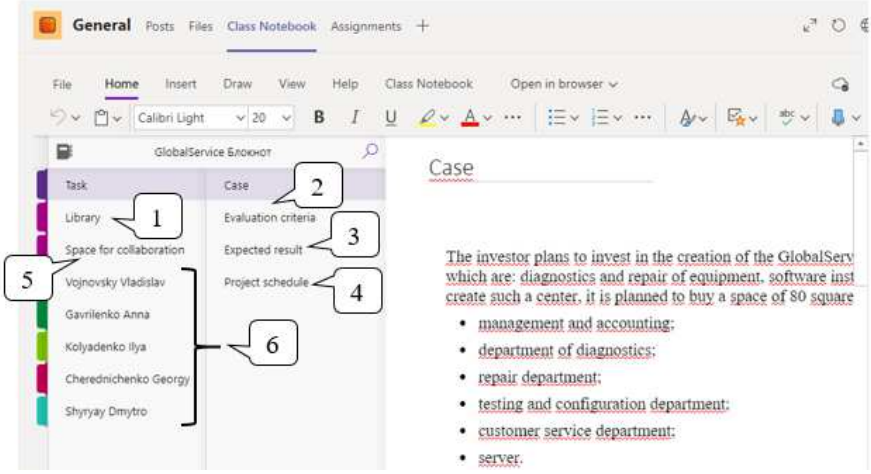

Fig. 6. An example of using Class Notebook service while implementing an interdisciplinary project

The teachers could place additional learning materials and the students could exchange useful materials needed to complete project tasks, create files and collectively fill them out in OneDrive cloud storage.

In the *Chat* service, the team members were able to communicate with each other while working on the project; they also received information about changes that occurred in the team (new tasks, files added to the repository, creation of new tabs in the team environment).

With the help of the *Conference* service students organized meetings (conferences) to work on the project.

Using the *Planner* service, the teams independently divided the project's stages into assignments, set timelines and appointed those in charge, monitored the execution of tasks by other team members (Fig. 7). While working on the project in a cloud-oriented environment, students had an opportunity to customize it to meet the needs of their team and integrate the professional tools needed to complete the project tasks.

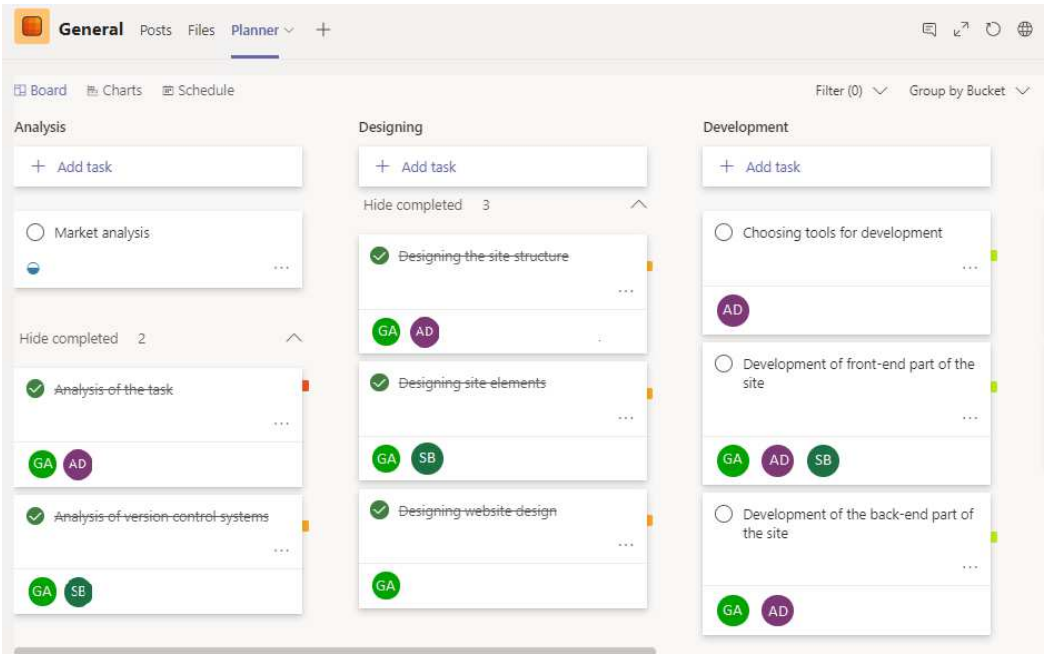

Fig. 7. An example of using Planner service while implementing an interdisciplinary project

The competence component determines the competences that are required for the organization of an interdisciplinary project. For a student, these are digital, professional and personal competences, such as teamwork, communication, time planning, ability to analyze information, making group decisions. Integral competence is formed due to the complex approach to the formulation and solution of the project task, which covers professional competences, starting from system analysis, network technologies, web technologies to business planning. The teacher needs digital competence, ability to organize group work, apply project teaching methods and use ICT tools in the learning process. The necessary competences of the administrator are the ability to administer servers, to protect data and network, and manage resources, services and users in the cloud-oriented environment.

2.3. The results of experimental work

During the experiment, two streams of students were selected. The control group (stream 1) performed an interdisciplinary project without the use of cloud services. For the

experimental group (stream 2), an environment organized in the cloud service Microsoft Teams, as described above, was proposed.

The assessment of the results of the interdisciplinary project is presented in Table 1.

Table 1

Distribution of points for each type of work of an interdisciplinary project

Criteria	The maximum score
Performing tasks in the discipline "System Analysis"	15
Performing tasks in the discipline "Computer networks"	15
Performing tasks in the discipline "Web-technologies and Web-design"	15
Performing tasks in the discipline "Economics and Business"	15
Presentation of results	20
Assessment of the contribution of each team member to the overall project result	20
Total	100

In order to assess the contribution of each participant in the overall project result, a survey was developed, where the students in the team independently distributed the points among the participants.

After the completion of the interdisciplinary project, the goal was to map students' academic achievements in each discipline on a 100-point scale. For this purpose, coefficients were introduced for each type of student work.

The distribution of points based on the coefficients was as follows: module 1-15 points; module 2-15 points; interdisciplinary project - 40 points; exam (credit) - 30 points. The mean grade of each group is presented in Fig. 8.

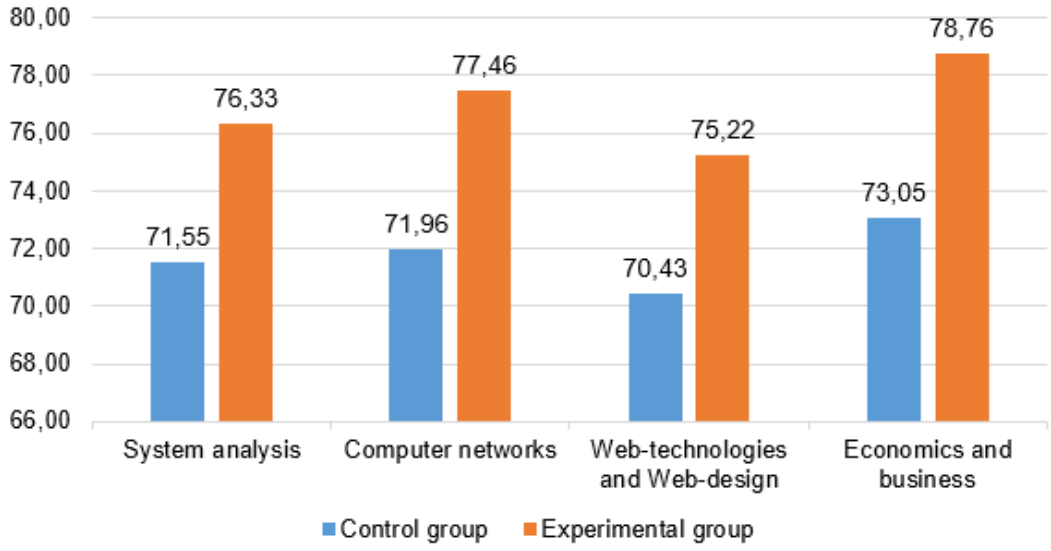

Fig. 8. The mean grade of the students in each discipline in the control and experimental groups

In addition to the results of the mean grade of the effectiveness of the hybrid cloud-oriented learning environment application for the implementation of interdisciplinary projects, the level of formation of digital competences was determined based on such indicators:

✓ the ability to develop strategies for the use of technology in accordance with the learning goals;

✓ the ability to use digital tools for data analysis and presentation in various ways;

✓ the ability to use digital tools for teamwork organization;

✓ the ability to select and use digital tools for planning and project management.

Fig. 9 shows the level of students' digital competences formation in the experimental and control groups.

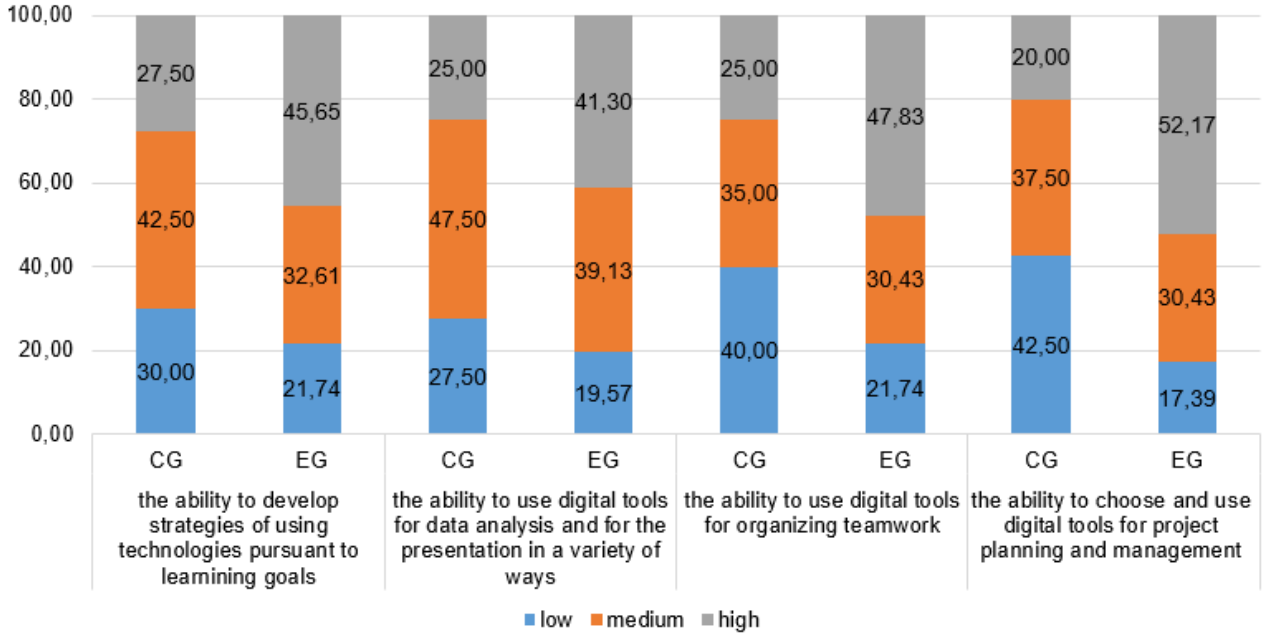

Fig. 9. The level of the students' digital competences formation in the experimental and control groups

Three levels of student digital competence were identified following the interdisciplinary project: low, medium and high. The general characteristics of components and levels of digital competence formation are presented in Table 2.

Table 2

Levels of digital competence formation

Components of digital competence	Level of formation	General characteristics of the student's abilities
The ability to develop strategies of using technologies pursuant to learning goals	low	Students can partially select tools.
	medium	The students select ICT tools with the help of a teacher and develop strategies for their use in accordance with learning objectives.
	high	Students independently select ICT tools and develop strategies for their use in accordance with learning objectives.
The ability to use digital tools for data analysis and for the presentation in a variety of ways	low	The student is familiar with digital data analysis tools, but rarely uses them.
	medium	The student has skills of working with digital tools for data analysis and presentation, but uses them only for urgent need.
	high	The student has skills of working with the necessary

		tools, can present the results of analysis in different ways, depending on the needs.
The ability to use digital tools for organizing teamwork	low	The student is acquainted with the basics of using digital tools of teamwork organization, does not apply them systematically, only in isolated cases.
	medium	The student is acquainted with the basics of using digital tools of teamwork organization, applies them not only in the organization of their own activities, unsustainable application in the organization of teamwork.
	high	The student is acquainted with the specifics of the use of digital tools for organizing teamwork, actively applies them not only in the organization of their own activities, but also in teamwork.
The ability to choose and use digital tools for project planning and management	low	The student uses the tools for planning and project management selected by the teacher, masters new services depending on the need and with the help of a teacher.
	medium	The student independently selects the necessary tools, but masters the work of the new services with the help of a teacher.
	high	The student independently selects the necessary tools and is able to independently use the new tools.

As can be seen from Fig. 10, more than 80% of the students in the experimental group noted that the level of digital competences was high and medium, while in the experimental group it was noted only by 60-70% of students.

In each of the study groups, a survey was offered in which students independently determined how their professional and personal skills developed during the project implementation according to a 10-point scale (Fig. 10-11).

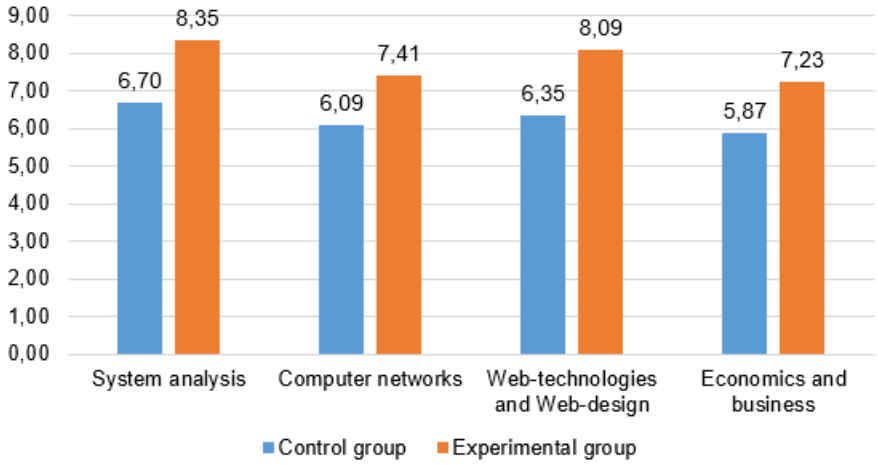

Fig. 10. The level of students' professional competences during the implementation of the interdisciplinary project

Assessing the growth of professional competences level, the students of the experimental group noted that the level of professional competences in the academic discipline "System Analysis" increased by 24,71% compared to the level of students in the

control group, whereas their level in "Computer Networks" increased by 21,74%, in "Web-technologies and Web-design" by 27,45%, in "Economics and Business" by 23,18%.

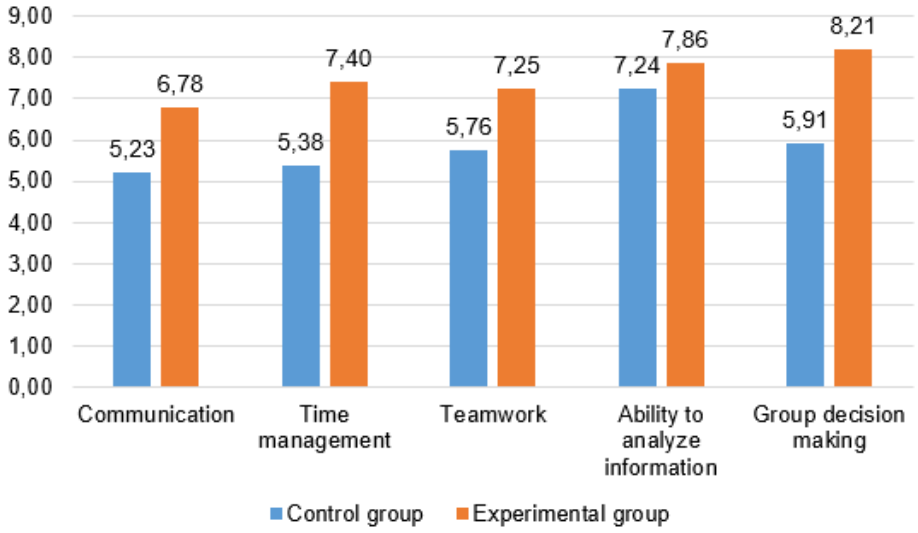

Fig. 11. The level of students' personal skills when implementing the interdisciplinary project

While assessing the increase of personal skills during the project implementation, students of the experimental group noted the growth of the following skills:

- ✓ communication – by 29,64% as compared to the students of the control group;
- ✓ time management – by 37,55%;
- ✓ teamwork – by 25,87%;
- ✓ ability to analyze information – by 8,57%
- ✓ group decision making – by 38,92.

In addition, the students of the experimental group pointed out the following benefits of using a hybrid cloud-oriented learning environment in the implementation of an interdisciplinary project:

- ✓ easy access to all necessary materials;
- ✓ convenience of building team communication;
- ✓ access to the environment at a convenient time and from any device;
- ✓ possibility of joint execution of tasks.

In order to evaluate the accuracy and relevance of the obtained findings, we calculated the students' mean grades in four academic disciplines involved in the project and put forward the hypothesis that the results are meaningful and not accidental. As a result, two independent distribution series were obtained.

To estimate the distribution series, we constructed a table of descriptive statistics (Table 3).

As the Table shows, the coefficients of variation in two distribution series are lower than 30%, the population is homogeneous and the results obtained can be trusted.

Student t-test is applied to test the hypothesis of equality of means with the aim of evaluating the significance of the obtained results.

Table 3

Descriptive statistics

Group	Number of	Mean grade	Standard deviation	Coefficient of variation	Coefficient of skewness	Excess kurtosis

	students					
CG	40	72	8.833	12,31%	0,439	-0,88
EG	46	77	9.879	12,84%	0,19	-1,27

For the application of this distribution, it is necessary that the source data be subordinated to the normal distribution law. To do this, the moment coefficient of skewness and the excess kurtosis were calculated. Since these data are not significantly different from 0, it is possible to assume the proximity of sampled data to normal distribution.

Data resulting from the performed calculations of evaluating the experiment give us the value of Student t-test equal to 2,531. The corresponding critical value of the t-test for the number of degrees of freedom 84 at $\alpha = 0,05$ level of significance is equal to 1,96. As we see, the Student t-test calculated according to experimental data exceeds the critical value of – 2,531> 1,96. Consequently, we reject the null hypothesis about the equality of population mean – testifying to the absence of the effect of the factor under consideration.

Accordingly, based on the results of the analysis we can state that the use of the hybrid cloud-oriented learning environment influences the learning outcomes.

3. CONCLUSIONS AND FURTHER RESEARCH PROSPECTS

Microsoft Teams-based cloud-oriented environment, which provides execution of tasks on communication, organization of teaching process, project management and makes it possible to integrate additional tools for arranging an interdisciplinary project, namely, professional, educational and the like, – is an effective environment for the development of the digital, professional and personal competences of the future IT specialist. Moreover, interdisciplinary projects contribute to the development of integral competence of future IT specialists.

When designing such an environment, it is necessary to take into account the requirements for the technology, communication and competence components, which must be interrelated and aimed at the accomplishment of the objectives of the interdisciplinary project in accordance with the defined content, methods and forms of training.

As a result of the implementation of an interdisciplinary project in such an environment, students' performance level grows on an average of 7,27%, while the growth of digital, professional and personal competences ranges from 15% to 38%.

Further research may be aimed at determining the impact of the proposed training technology on the development of integral competence and developing relevant measurement indices.

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ГІБРИДНЕ ХМАРО ОРІЄНТОВАНЕ НАВЧАЛЬНЕ СЕРЕДОВИЩЕ ДЛЯ ПРОЄКТНОЇ КОМАНДНОЇ РОБОТИ МАЙБУТНІХ ІТ-ФАХІВЦІВ

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Анотація. У статті запропоновано технологію розробки та впровадження хмаро орієнтованого середовища для електронної підтримки міждисциплінарних проєктів у навчальному процесі майбутніх ІТ-фахівців. Для організації такого проєкту була розроблена модель гібридного хмаро орієнтованого навчального середовища з компетентнісним, комунікаційним та технологічним компонентами. На основі розробленої моделі було спроєктоване хмарне середовище на базі MS Teams для командної проєктної роботи. Таке середовище поєднало всі необхідні інструменти та сервіси для реалізації міждисциплінарного проєкту. Зокрема технологічний компонент регулює зміст, методи та форми навчання під час реалізації проєкту. Відповідно до змісту міждисциплінарного проєкту було визначено методи і форми навчання, як традиційні, так і хмаро орієнтовані. Це середовище забезпечувало взаємодію між викладачами різних дисциплін і команд студентів. Програмний компонент складається з інструментів для комунікації, управління проєктами та розміщення навчальних ресурсів, які є складовими MS Teams, і доповнюється додатковими інструментами, які інтегруються з ним, наприклад, професійно орієнтованими та інструментами для презентації результатів роботи. Викладачі можуть додатково інтегрувати необхідні курси та засоби е-навчання. Аналіз даних експериментальних досліджень показав, що гібридне хмаро орієнтоване навчальне середовище MS Teams, яке забезпечує виконання завдань з комунікації, управління навчанням, управління проєктами та дозволяє інтегрувати додаткові інструменти для організації міждисциплінарного проєкту, а саме професійні та навчальні, – це ефективне середовище для розвитку цифрових, професійних і особистісних компетентностей майбутніх ІТ-фахівців. Крім того, міждисциплінарні проєкти сприяють розвитку інтегральної компетентності майбутніх ІТ-спеціалістів. Експериментальне дослідження було проведене на базі Національного університету біоресурсів і природокористування України із залученням студентів 3-го курсу спеціальності 122 «Комп'ютерні науки».

Ключові слова: гібридне хмаро орієнтоване навчальне середовище; командна робота; ІТ-студенти; міждисциплінарний проєкт; цифрові компетенції; професійні компетенції; м'які навички.

ГИБРИДНАЯ ОБЛАЧНО ОРИЕНТИРОВАННАЯ УЧЕБНАЯ СРЕДА ДЛЯ ПРОЕКТНОЙ КОМАНДНОЙ РАБОТЫ БУДУЩИХ ИТ-СПЕЦИАЛИСТОВ

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Аннотация. В статье предложена технология разработки и внедрения гибридной облачно ориентированной учебной среды для электронной поддержки междисциплинарных проектов в учебном процессе будущих IT-специалистов. Для организации такого проекта была разработана модель облачно ориентированной среды с компетентностным, коммуникационным и технологическим компонентами. На основе разработанной модели было спроектирована облачная среда на основе MS Teams для командной проектной работы. Такая среда соединила все необходимые инструменты и сервисы для реализации междисциплинарного проекта. В частности, технологический компонент регулирует содержание, методы и формы обучения при реализации проекта. Согласно содержанию междисциплинарного проекта были определены методы и формы обучения как традиционные, так и облачно ориентированные. Эта среда обеспечила взаимодействие между преподавателями различных дисциплин и команд студентов. Программный компонент состоит из инструментов для коммуникации, управления проектами и размещения учебных ресурсов, которые являются составными MS Teams и дополняется дополнительными инструментами, которые интегрируются с ним, например, профессионально ориентированными инструментами и инструментами для презентации результатов работы. Преподаватели могут дополнительно интегрировать необходимые курсы и средства электронного обучения. Анализ данных экспериментальных исследований показал, что гибридная облачно ориентированная учебная среда MS Teams, которая обеспечивает выполнение задач по коммуникации, управлению обучением, управлению проектами и позволяет интегрировать дополнительные инструменты для организации междисциплинарного проекта, а именно профессиональные и учебные, – это эффективная среда для развития цифровых, профессиональных и личностных компетентностей будущих ИТ-специалистов. Кроме того, междисциплинарные проекты способствуют развитию интегральной компетентности будущих ИТ-специалистов. Экспериментальное исследование было проведено на базе Национального университета биоресурсов и природопользования Украины с привлечением студентов 3-го курса специальности 122 «Компьютерные науки».

Ключевые слова: гибридная облачно ориентированная учебная среда; командная работа; ИТ-студенты; междисциплинарный проект; цифровые компетенции; профессиональные компетенции; мягкие навыки.

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