A methodology for flipped learning in a cloud-oriented environment: enhancing future IT specialists' training

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Abstract. The article discusses the components of a cloud-oriented environment for flipped learning in higher education institutions. It presents a methodology that utilizes various services and resources available in the university's cloud-oriented environment. The methodology is divided into three stages: preparatory, basic, and integrated. During the preparatory stage, students collaborate on collective projects within one discipline using Microsoft Teams. The aim is to develop general competencies. At the basic stage, students engage in tasks such as mini-projects, group projects, and individual projects while studying professionally-oriented disciplines. These tasks are performed using the GitHub cloud service. The integrated stage involves working on interdisciplinary projects that draw from multiple disciplines. The tasks for these projects are formed based on the study of several disciplines and utilize the Jira service. The article investigates the effectiveness of this methodology for flipped learning by analyzing its application in the university's cloud-oriented environment.[1]

Keywords: student engagement, flipped learning, cloud computing, IT education, project management, MOOCs

1. Introduction

Sustainable development depends on innovation and the introduction of ICT in various sectors of the economy and livelihoods [28]. Providing inclusive and equitable quality education, promoting lifelong learning for all, is one of the global goals of sustainable development. The issue of training quality IT professionals is especially relevant in the context of achieving sustainable development goals, as modern innovation is based on the widespread use of IT.

[1]This is an extended and revised version of the paper presented at the 1st Symposium on Advances in Educational Technology [12].

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Higher education institutions are constantly confronted with educational and technological challenges involved in preparing future IT specialists. Teachers are faced with the task of finding new approaches to solving the problem of improving the quality of the educational process and developing students' professional and personal skills. Moreover, employers' expectations of professional qualification requirements must be met. In addition to professional competencies, teamwork, problem-solving, and communication skills, so-called soft skills, should be addressed in future IT specialists [37].

Flipped learning is a way of creating a learning ecosystem that has proven to be effective. Flipped classrooms connect people and provide them with a variety of content and technology. This increases learner engagement as there is activity-based, practical learning during classroom time. Flipped learning also boosts healthy interaction between members in a mutually beneficial manner, which is an essential function of an ecosystem. Blended learning, interaction between members, and informal learning are other characteristics of a flipped classroom that take you closer to developing a learning ecosystem [2, 20].

We are looking at flipped learning as a way of creating a learning ecosystem, we realise how effective it is. Flipped classrooms connect people and provide them with a variety of content and technology. This increases the engagement of the learners as there is activity-based, practical learning in classroom time. Flipped learning also boosts healthy interaction between members, in a mutually beneficial manner, which is the essential function of an ecosystem. Blended learning [22, 23, 27, 30], interaction between members and informal learning are other characteristics of a flipped classroom that take you closer to developing a learning ecosystem.

Case studies have increasingly demonstrated the positive impact of the flipped approach on student and teacher motivation, class attendance, and academic performance [3, 6, 13]. These studies provide measurable evidence of the benefits associated with implementing the flipped learning model.

Innovative approaches in higher education are moving away from traditional teacher-centered instruction and embracing student-centered learning [1, 32]. This shift recognizes the importance of engaging students actively in the learning process and fostering their autonomy.

The *purpose* of this article is to substantiate the components of a cloud-oriented environment and explore its application in flipped learning for training future information technology specialists. The study aims to investigate the effectiveness of a developed methodology that leverages the cloud-oriented environment to facilitate project-based learning

2. Theoretical background

The number of alternative teaching methods being explored in Computer Science (CS) education is increasing to address pedagogical and financial challenges [15, 26, 31].

A flipped classroom typically exhibits two common characteristics:

1. An easily adaptable learning environment that facilitates active learning and enables students to develop diverse skills and competencies [7, 18, 21, 34].
2. A student-centred learning culture [3, 4].

According to the Flipped Learning Network, the flipped classroom approach is built on four pillars [9]. Teachers aiming to implement this approach should consider the following elements:

- Flexible environments that accommodate flipped learning.
- A shift in learning culture to foster student-centeredness.
- Intentional content designed for flipped learning.
- The involvement of professional educators.

The concept of flipped learning involves providing students with lectures in video format and supplementary materials to review as homework. This allows students to maximize their understanding before engaging in in-class activities and problem-solving exercises. The flipped classroom serves as a platform for achieving a collaborative and organic learning environment.

To address the challenges of the 21st-century workplace, businesses have adopted an organic learning environment. Similarly, universities and accreditation bodies in business schools are moving towards developing competency-based curricula that foster lifelong learning skills through self-directed learning [29].

Maher et al. [19] presented experiences in developing flipped courses, focusing on the temporal structure, alternative sources for video instruction, and strategies for active learning. The course design involved video instruction preceding skills development and concept learning. In-class lab activities scaffolded open-ended homework projects, promoted peer learning, and in-class quizzes facilitated the discovery of misconceptions.

Silva et al. [33] analyzes the effects of learning analytics on engineering students' self-regulated learning in a flipped classroom. The results demonstrate that learning analytics can be used to promote self-regulated learning in flipped classrooms, helping students identify strategies that can enhance their academic performance. Flipped learning approaches involve students using technology to access lectures and other instructional resources outside the classroom, engaging them in active learning during in-class time [25].

Smyrnova-Trybulska, Morze and Kuzminska [34] describe scenarios and collaboration tools for students' practical activities. They provide examples of learning objects that represent resources for independent study and research. Additionally, they propose criteria for assessing the effectiveness of the proposed model of flipped learning.

The active learning techniques employed in flipped classrooms integrate student-centered learning methods such as cooperative learning, problem-based learning, project-based learning, and peer-assisted learning. These approaches foster collaborative work among students to develop and achieve their learning goals [1].

The flipped learning technology aims to transition the educational process from passive student learning to active learning, where future specialists participate in collaborative work, carry out team projects, and solve practical problems in the classroom using theoretical knowledge acquired prior to class. By providing students with basic theoretical knowledge before class, the teacher becomes a facilitator, enabling students to deepen their knowledge and practical skills during class and independently manage their own educational process.

The scheme of the educational process organization under the flipped learning technology for future specialists in information technologies is presented in figure **??**.

Prior to class, students need to acquire basic theoretical knowledge in each academic subject using the resources of the e-learning course (ELC) and further deepen their knowledge independently by studying various MOOCs recommended by teachers. During class, students plan joint activities, work on projects as a team, and perform practice-based tasks. In the classroom,

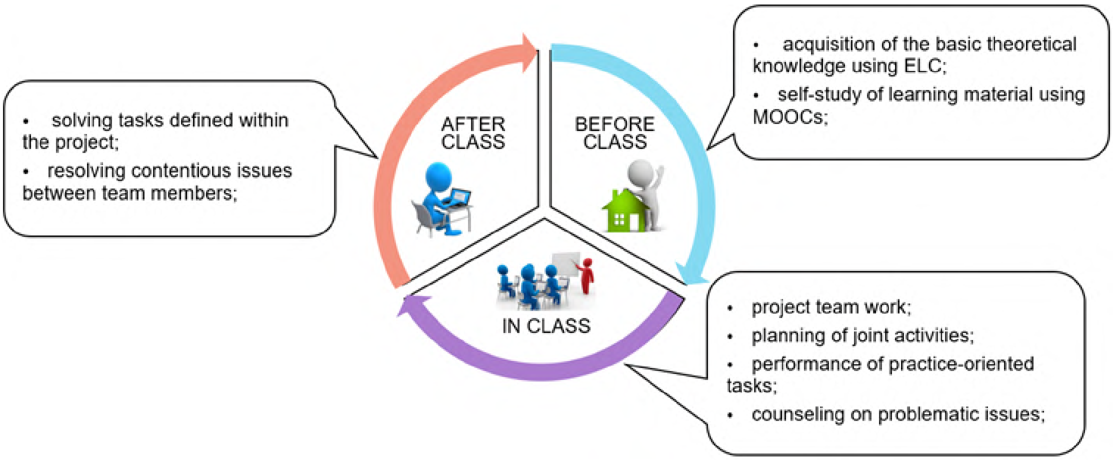

Figure 1: The scheme of the educational process organization under the flipped learning technology.

students consult with teachers on problematic issues. After class, student teams perform tasks assigned to each participant within the project and address controversial issues that arise among team members regarding project tasks.

The use of modern information technologies further enriches the flipped learning process and fosters the skills needed by future IT specialists. At the World Economic Forum in 2020, it was determined that it is important to pay attention to the ways and forms of organizing the educational process. Information technologies, with an emphasis on teamwork, creativity, and learning through games that develop critical thinking, support students' initiative outside educational programs [10, p. 44].

A cloud-based environment for organizing the learning process through flipped learning should provide e-support for students' and teachers' activities at the stages "before class", "in class", and "after class". The notion and possibility of using a learning environment are considered by Burov [5], Demianenko [8], Ivaniuk [14], Kovtoniuk et al. [17], Vakaliuk [36], Voloshynov et al. [38].

Spirin et al. [35] describes a cloud environment for studying the Computer Networks course that was deployed at the Faculty of Physics and Mathematics of Ternopil Volodymyr Hnatyuk National Pedagogical University. It investigates the effectiveness of blended learning in such an environment.

Supported by information and communication technologies, teachers have many options for improving the effectiveness of teaching, particularly in organizing teamwork projects in the process of training future IT specialists.

The cloud-oriented environment at the National University of Life and Environmental Sciences (NULES) of Ukraine is designed for training future IT specialists using flipped learning technology (figure 2). Korolchuk [16] analyzed selection criteria for cloud services and resources that are appropriate for training future IT professionals.

The university's cloud-oriented environment provides IT majors with a variety of resources and services that enable them to use:

- E-learning courses (ELC) in accordance with the curriculum for training specialists using the Moodle LMS, Khan Academy, online courses from Microsoft and Cisco leading technology companies, respectively, Microsoft Imagine Academy, Cisco Networking Academy, Massive Open Online courses (MOOCs), such as Coursera, Udemy, Prometheus, edX, Khan Academy, and others prior to classes within the framework of independent work with e-resources.
- Professionally-oriented software and cloud services such as Microsoft Office 365, Visual Studio, draw.io, services for collective IT development (GitHub, Bitbucked, DeployBot, Phabricator, BeanStalk), Miro in the classroom.
- Services to manage collective projects such as Microsoft Teams, Jira, Trello, Asana, YouTrack for cooperation outside the university.

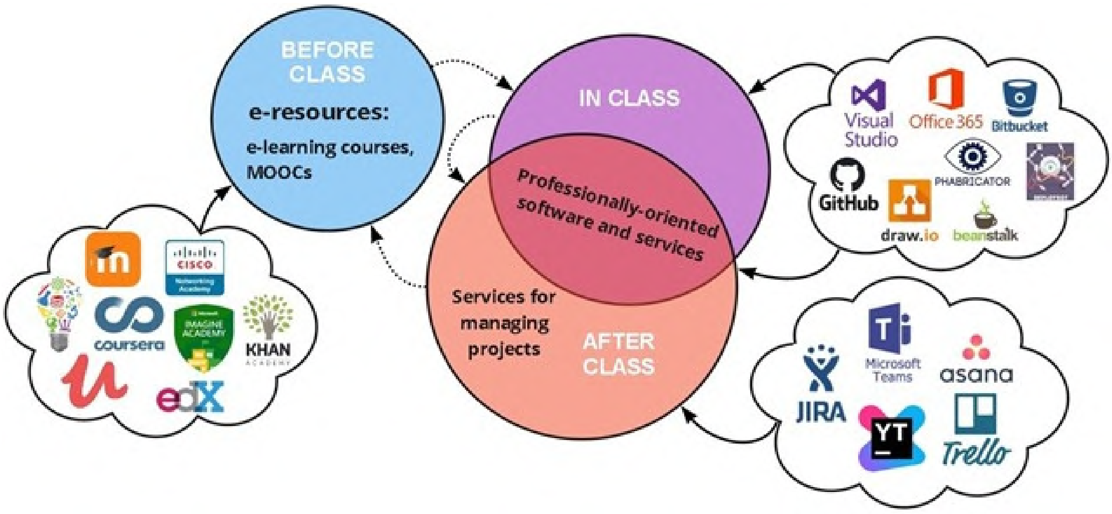

Figure 2: Components of the cloud-oriented environment for flipped learning.

By utilizing these resources and services in flipped learning technology, students can participate in collaborative work and carry out team projects while discussing and solving practical problems in the classroom.

The design of a cloud-oriented environment for the implementation of projects enables teachers to choose the means available to complete the project's tasks, integrate the necessary services and resources into the created environment, and provide communication between educators who teach the project disciplines and teams of students. Students have the opportunity to effectively plan project implementation steps, distribute tasks among team members, monitor their implementation, and organize teamwork to create the end product of the project.

To understand students' attitude toward the cloud-oriented environment of the university, we have defined three criteria for evaluating them from the standpoint of functionality of the cloud-oriented environment:

1. To perform professional tasks.

2. To implement flipped learning technology.
3. To manage project implementation.

Indicators under the first criterion include:

- Accessibility (ability to work from any device).
- Reliability (high-quality functioning of the cloud-oriented environment).
- Flexibility (designed and used in line with learning objectives).
- Expediency (need for use to solve problems).
- Convenience (clarity and ease of use).
- Support for processes (communication, collaboration, cooperation, planning, and control).
- Teamwork (the ability to organize teamwork, create team projects).
- Integrity (ensuring a continuous educational process).
- Integration with other cloud services.
- Support for various programming technologies.
- The ability to access open code software.

Indicators under the second criterion are as follows:

- Availability of training resources in a cloud-oriented environment.
- Completeness of educational material for students to acquire theoretical knowledge independently.
- Completeness of training material necessary for practical tasks.
- Convenience for independent preparation for the class.
- Convenience of interaction among team members in practical activities.
- Convenience for self-control.
- Convenience for checking the level of acquired knowledge.

Indicators under the third criterion are as follows:

- Ease of team work organization.
- Convenience in planning the work on a collaborative project.
- Ease of roles and areas of responsibility allocation for each team member.
- Convenience of controlling the timing of each task.
- Convenience of communication among team members.
- Ease of interaction among team members during team development.
- Ease of checking completed tasks.
- Ease of managing software versions.

In an article by Glazunova et al. [11], the efficiency of the cloud-oriented environment is determined by these three categories and evaluation indicators. Students were interviewed before and at the end of a collective project on flipped learning technology using a cloud-oriented environment.

The most important indicators identified by students in evaluating the performance of a cloud-oriented environment were support for the process, support for various programming technologies, integration with other cloud services, and accessibility. The concordance coefficient was 0.693, indicating an average degree of agreement among experts' opinions. The evaluation results determining the performance of a cloud-oriented environment are presented in table 1.

The weights of the considered parameters were calculated based on the sums obtained.

Table 1
Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	Teaching staff weight	Students weight
accessibility (ability to work from any device)	0.02	0.11
reliability (high-quality functioning of the cloud-oriented environment)	0.08	0.04
flexibility (designed and used in line with learning objectives)	0.18	0.07
expediency (need for use to solve problems)	0.08	0.03
convenience (clarity and ease of use)	0.08	0.06
support for processes (communication, collaboration, cooperation, planning and control)	0.15	0.17
teamwork (the ability to organize teamwork, create team projects)	0.12	0.09
integrity (ensuring a continuous educational process)	0.11	0.02
integration with other cloud services	0.12	0.13
support of various programming technologies	0.05	0.16
the ability to access open code software	0.01	0.10
Total	1	1
Concordance coefficient	0.742	0.693
Calculated χ^2	59.36	235.62
Table χ^2 (k=10, α = 0.05)	18.309	18.309

When evaluating the performance of a cloud-oriented environment, the teaching staff found out that flexibility, support for the process, teamwork, and integration with other cloud services were the most important indicators. The concordance coefficient was 0.742, which indicates a high level of agreement of experts' opinions. Evaluation of the results of determining the effectiveness of the cloud-oriented environment for the project activity in table 2.

When evaluating the effectiveness of a cloud-oriented environment for project activity, teachers identified the following indicators as the most important: convenience of organizing teamwork, ease of interaction among team members during team development, and ease of planning for a team project. According to students, the most important indicators are ease of teamwork organization, ease of interaction among team members during team development, and ease of managing software (program code) versions. The evaluation results for determining the effectiveness of a cloud-oriented environment for flipped learning are presented in table 3.

When evaluating the effectiveness of the cloud-oriented environment for flipped learning, the teachers noted that the convenience of checking the level of acquired knowledge, completeness of educational material for students' independent mastering of theoretical knowledge, and

Table 2
Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	Teaching staff weight	Students weight
ease of teamwork organization	0.24	0.23
convenience in planning the work on a collaborative project	0.19	0.12
ease of roles and areas of responsibility allocation for each team member	0.06	0.03
convenience of controlling the timing of each task	0.04	0.09
convenience of communication among the team members	0.01	0.12
ease of interaction of team members during team development	0.22	0.21
ease of checking completed tasks	0.14	0.02
ease of managing software (program code) versions	0.06	0.18
Total	1	1
Concordance coefficient	0.918	0.813
Calculated χ^2	51.48	193.49
Table χ^2 (k=7, α = 0.05)	14.068	14.068

Table 3
Evaluation of the results for determining the performance of a cloud-oriented environment.

Indicators	Teaching staff weight	Students weight
availability of training resources in a cloud-oriented environment	0.11	0.19
completeness of educational material for students to acquire theoretical knowledge independently	0.23	0.04
completeness of training material necessary for practical tasks	0.17	0.25
convenience for independent preparation for the class	0.06	0.13
convenience of interaction of team members in practical activity	0.14	0.10
possibility of self-control	0.02	0.24
convenience for checking	0.27	0.04
Total	1	1
Concordance coefficient	0.728	0.748
Calculated χ^2	34.944	152.592
Table χ^2 (k=6, α = 0.05)	12.593	12.593

completeness of educational material needed to perform practical tasks were the most important indicators.

3. Method

The cloud-oriented environment of the university is the main component of the flipped learning system for training future IT professionals. According to students, this environment should meet the following requirements: process support (communication, collaboration, cooperation, planning, and control), ease of distribution of roles and areas of responsibility of each team member. Teachers identified the following indicators of the effectiveness of this environment with more weight than students: convenience of checking the level of acquired knowledge, flexibility (designed and used according to learning objectives), ease of teamwork, completeness of educational materials for practical tasks.

The methodology for using a cloud-based environment for flipped learning of future specialists in information technology consists of three stages: preparatory, basic, and integrated. The purpose of the first (preparatory) stage is to form teamwork skills, communicative and management skills during the performance of collective projects within one discipline using services for project management. The preparatory stage is important for forming different students' competencies, not only professional competencies in IT project development. The need for independent performance of a part of the project and collaboration contributes to the formation of soft skills, particularly communication and leadership.

In the preparatory stage, the Microsoft Teams cloud service was used to perform tasks and organize team work. This service allows you to create an environment for teamwork, set tasks for team members, plan collaboration, and integrate additional tools needed to complete project tasks.

In the curriculum for training IT specialists at the first stage, which is the beginning of the methodology, it is necessary to form soft skills that are needed for successful project implementation. These include teamwork skills, communication, and management skills. For this purpose, the discipline Information Technology was chosen. During this course, students are proposed a project to perform within the educational practice. Throughout each stage of project work within the discipline, students develop various abilities such as organizing joint activities and forming a capable team, establishing a communication system in a team using appropriate cloud services, taking control of situations, uniting a group, and building effective team interactions to solve certain tasks.

Since the educational practice (technological, project-technological) is carried out after the completion of theoretical training, it is important to form tasks for educational practice based on a practice-oriented approach. Thus, educational practice is a stage of students' educational activity during which they apply acquired skills from certain disciplines. Educational practice in the university is an important tool for professional self-determination and future professional development.

During the educational practice, special attention is paid to modern methods, forms, tools, instruments, and services in the field of students' future profession. This is done in accordance with the educational degree and aims to form knowledge, professional skills, and abilities for independent decision-making while working in real market-oriented and production-oriented conditions. It also educates students about the need to systematically update their knowledge and creatively apply it in practice. At this stage, it is important to focus on the application of problem-based, project-based, and practice-oriented methods in student learning. One such method is flipped learning, which involves students studying theoretical material independently outside the classroom and performing practice-oriented tasks during classroom practice time.

The procedure for using the cloud service Microsoft Teams for flipped learning is shown in figure 3.

By organizing collective projects using the cloud service Microsoft Teams, students develop professional competencies and soft skills. This includes the formation of teamwork skills,

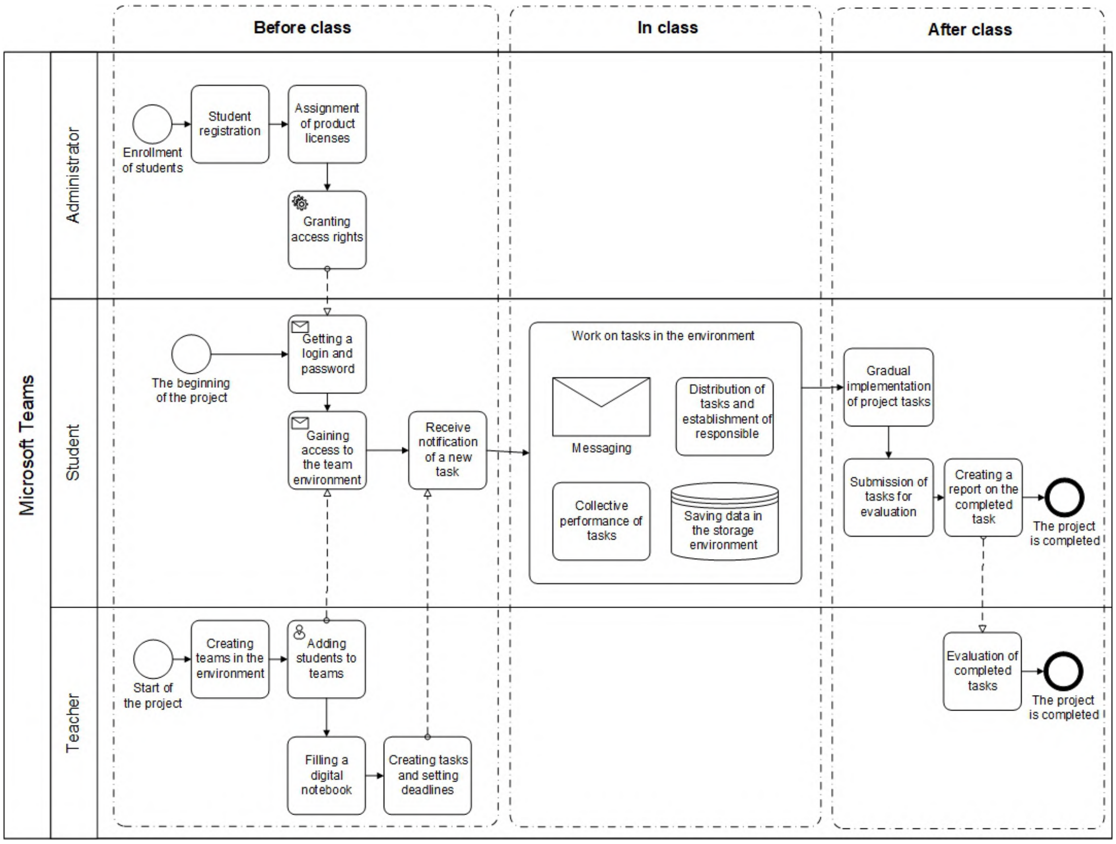

Figure 3: Procedure for using the MS Teams cloud service for flipped learning.

communication, and management skills required by future IT professionals who use the flipped learning method.

At the basic stage, the GitHub cloud service was used. This service allows students to use a built-in code editor, work collaboratively on program code, manage code versions, and discuss it with other team members. It meets the criteria for an effective cloud-based environment by providing access to open-source software, convenient software version management, and facilitating team collaboration during practice performance.

The second stage aims to develop future IT professionals' professional competencies and personal effectiveness through participation in mini-projects, group and individual project tasks, and course projects within professional disciplines. These projects utilize services for collective IT development. During this stage, collective mono-projects are proposed as part of the study of professional disciplines or course work. This approach ensures the formation of future IT professionals' professional competencies and soft skills using services for collective IT development in the context of flipped learning. The skills developed include the ability to define and achieve goals, prioritize tasks within a limited time, estimate time and skills required for developing an IT project, and more. Disciplines such as Object-Oriented Programming, Software Development Technologies, Cross-Platform Programming, etc., are identified as effective for developing these skills.

To facilitate the formation of these skills, it is important to choose appropriate teaching methods and forms that allow students to acquire the necessary abilities. Alongside the project-based method, blended learning is recommended for studying theoretical material and performing tasks. Blended learning involves students learning part of the material online and independently managing their time and pace of learning to complete tasks. To organize projects in combination with flipped learning, it is advisable to use ELC (Electronic Learning Content) in conjunction with cloud services for IT project development.

The procedure for using the GitHub cloud service for flipped learning during the implementation of a mono-project within professionally-oriented disciplines is illustrated in figure 4.

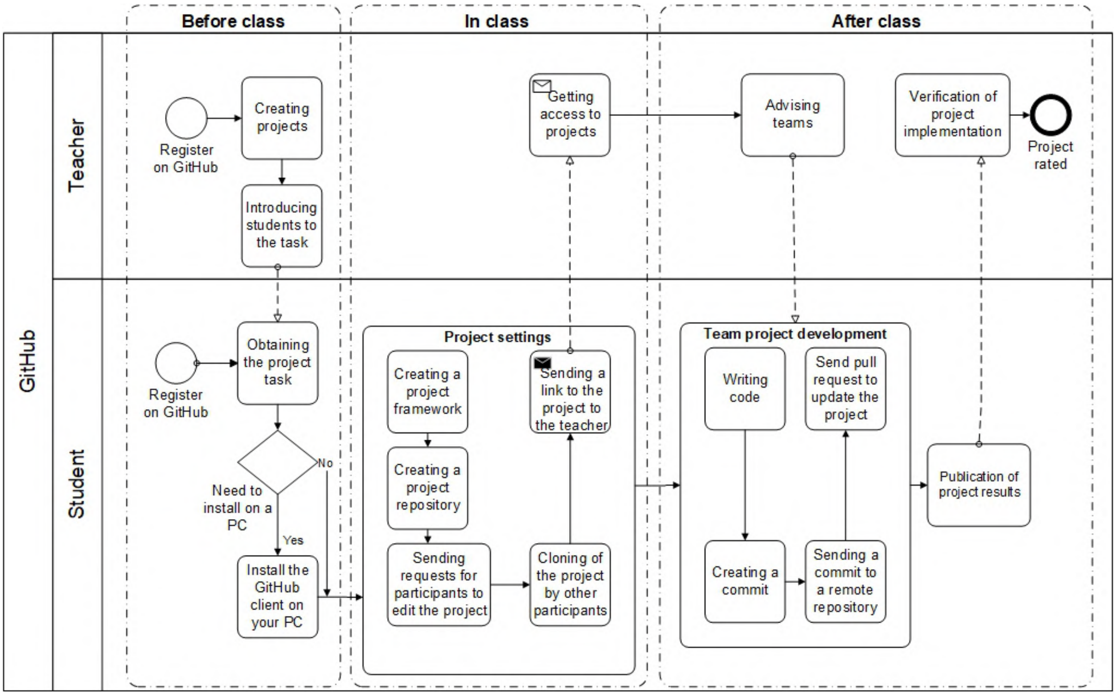

Figure 4: Procedure for using the GitHub cloud service for flipped learning.

At the integrated stage, project management services such as Jira, Trello, and Asana were used. These services allow students to plan collaborative work during the performance of interdisciplinary projects. By utilizing these services, IT students develop professional competencies, strategic management, personal effectiveness, and information management skills. They also gain IT project management skills while participating in interdisciplinary projects that involve project management and collective IT development.

At the third stage of the methodology, interdisciplinary projects are recommended for implementation. The content of an interdisciplinary project in three disciplines: Systems Analysis, Web Technology and Web Design, and Economics and Business was determined. This aims to develop personal effectiveness skills, strategic and information management skills, as well as IT project development and project management skills.

According to the content of the interdisciplinary project defined by the teachers, it is necessary to choose methods and forms of teaching, both traditional and cloud-oriented. Traditional forms and methods of teaching should be used in the study of theoretical material and practical work in the disciplines involved in the project. In particular, the method of flipped learning should be used to develop theoretical material using the resources of the ELC during independent work. During classroom work, it is necessary to organize students into groups to implement practice-oriented tasks that are part of the project. Cloud-oriented teaching methods should be used for communication and joint work on project tasks in a cloud-oriented environment. Thus, it is necessary to combine the project method with flipped learning when students study theoretical material and perform practical work independently. In class, they will work on solving project problems. The procedure for using the cloud service for inverted learning during the implementation of an interdisciplinary project is developed using Jira as an example (figure 5).

The use of this process allows future information technology professionals to form professional competencies in the professional disciplines involved in the project as well as soft skills such as strategic management skills, personal effectiveness, information management, and IT project management skills.

The students were offered to implement the cross-disciplinary project on the topic of "Web-oriented system for the IT industry". The purpose of this project was to carry out systematic analysis, develop a web-oriented system, and evaluate the investment attractiveness of the developed system. The project content included developing a project for starting their own

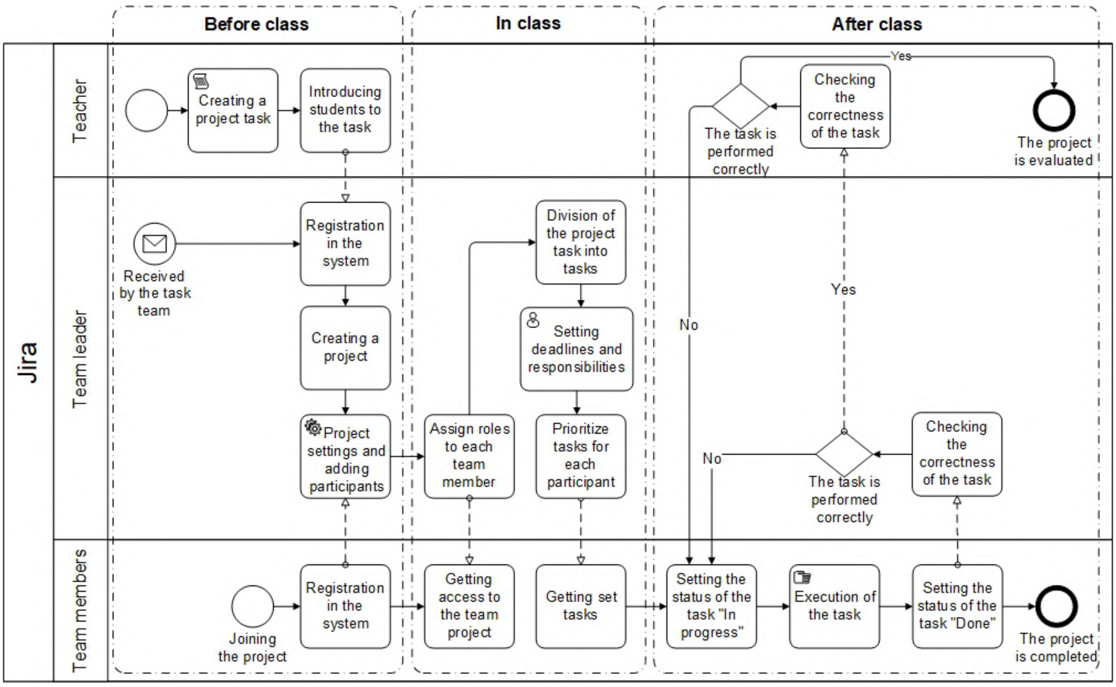

Figure 5: Procedure for using the Jira cloud service for flipped learning.

IT business. This involved conducting an analysis of the IT services market, carrying out structural, functional, and object-oriented analysis of the domain, designing the database and system functionality, developing a web-based system for the IT company, creating a business plan for the company, calculating the payback of the project, and strategizing the company's development.

The implementation of this collaborative project under flipped learning technology involves eight stages:

1. Setting a task and processing theoretical material.
2. Structuring the task and subdividing it into specific tasks.
3. Role distribution, definition of terms, and responsibilities.
4. Performance of basic tasks.
5. Joint work of the task team.
6. Assessment of the quality of the task.
7. Drawing up a report on the work performed.
8. Presentation of results.

The teamwork was subdivided into 3 parts, according to the tasks of each academic discipline that were part of the cross-disciplinary project. In the course of completing the tasks in the System Analysis academic discipline, the students had to conduct an analysis of the IT services market, choose the profile of the future company, develop the functionality of the future business, carry out structural-and-functional and object-oriented analysis, design information support, and describe the specification of management processes. In the course of Web Design and Web Technologies academic disciplines, the students developed the website of the future company and integrated it into the information management system of the company. The tasks in the Economics and Business course required students to analyze the necessary tools to start their own business, develop a business plan for the future company, formulate a strategy for its further development, calculate basic income and expenditure, as well as evaluate its economic efficiency and investment attractiveness.

Before the start of training (before class), instructions were prepared for each project task, and the necessary training materials were made available in ELCs for each academic discipline. The teaching materials at ELCs were tailored to the students' learning styles. In line with the findings presented in [24], the same material was often presented in various formats. Consequently, students studied fundamental theoretical materials in the ELCs of their respective academic disciplines. They familiarized themselves with the project objectives, registered for MOOCs, and selected courses that aligned with their learning style to independently study the required material. Lectures were conducted on a rotating basis for each academic discipline according to the schedule, allowing students to delve into the theoretical material necessary to complete their assignments. Additionally, teachers provided students with access to specialized software and project management services relevant to each stage of the interdisciplinary project.

During class (in class), all students were required to participate in weekly interactive lectures and laboratory work. These sessions aimed at developing a project based on tasks from three different academic disciplines within the cross-disciplinary project. The first session involved a detailed introduction to the subject and tasks of the project in each academic discipline. Students formed teams of four members each and assigned roles and responsibilities within their teams. They defined implementation terms and appointed responsible team members for each task. Students were expected to understand the problem, evaluate its complexity, explore solution options, divide tasks into sub-tasks, and apply theoretical and practical knowledge acquired prior to classes to solve project tasks. Teachers guided students on course progress during class sessions and helped them acquire basic skills using specialized software and university cloud-oriented services.

After class, team members collaborated on project tasks across academic disciplines using project management and IT-team services. Students evaluated their own work as well as that of other team members. If necessary, they refined tasks to meet professional standards and created presentation reports reflecting their team's results at all stages of the project. Finally, each team presented their project results for evaluation by teachers and participants from other teams to assess readiness for implementation.

Figure 6 shows a diagram of one of the cycles of fulfilling the tasks of a cross-disciplinary project under the flipped learning technology using the cloud-oriented university environment.

Tables 4-6 defines in more detail the types of activities in the process of the implementation of each stage of the project, during which the students develop professional, integrated, self-educational competences and soft skills, for each of the above stages of the cross-disciplinary project using a cloud-oriented environment.

Therefore, the execution of these cross-disciplinary project tasks encompassed various stages, leading to the cultivation of professional, integrated, self-educational competences. Additionally, it fostered the development of communication, interpersonal, leadership, teamwork, and time management skills – commonly referred to as "soft skills".

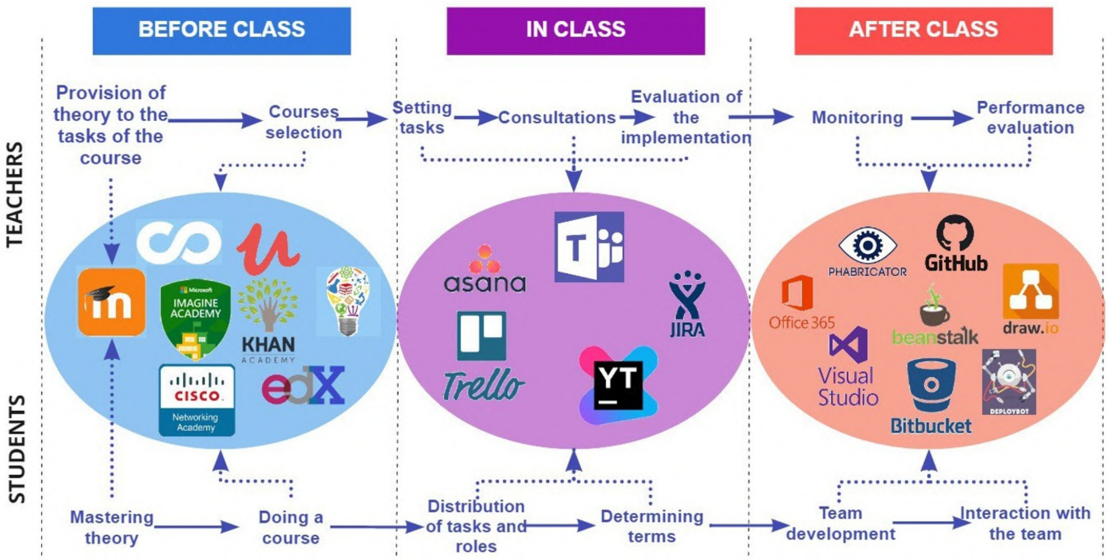

Figure 6: The diagram of one cycle of the cross-disciplinary project under the flipped learning technology using the cloud-oriented university environment.

Table 4
Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment before class.

Contents of the stage	Activity	Tools	Competence
Setting tasks and mastering of the theoretical material	getting acquainted with the aim and tasks of the project; studying the theoretical material in ELC; registration and selection of MOOC; doing online courses	LMS Moodle; Cisco Academy; Prometheus; Coursera; Microsoft Imagine Academy; Udemy; Khan Academy	self-educational; professional; ability to search, process and analyze information from various sources

Table 5
Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment in class.

Contents of the stage	Activity	Tools	Competence
Structuring the material and dividing it into specific tasks	evaluation of the task complexity; search for solutions to the problem; division of the task into separate tasks	Microsoft Teams; Jira; Trello; Asana; YouTrack	ability to work in a team; knowledge and understanding of the subject area; ability to make decisions
Allocating roles, appointing people in charge, setting the date	allocation of roles and areas of responsibility of each team member; appointment of those responsible for each task	Microsoft Teams; Jira; Trello; Asana; YouTrack	ability to work in a team; ability to make decisions
Performing basic tasks	solving practical tasks according to the aim of the task performance consultation with the teacher on problematic issues	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	professional; integral; the ability to apply knowledge in practical situations

4. Results

The study was conducted over a period of 3 years and involved students majoring in Computer Science and Computer Engineering at the Faculty of Information Technologies of NULES of Ukraine. The students were divided into two groups: an experimental group of 115 students majoring in Computer Science and a control group of 109 students majoring in Computer Engineering. The control group did not have access to the resources and services of the cloud-oriented environment and followed the traditional flipped learning approach, completing project tasks according to the predefined stages. On the other hand, the experimental group utilized the cloud-oriented environment for inverted learning, following a three-stage methodology:

Table 6
Organization of the cross-disciplinary project under the flipped learning technology using the cloud-oriented environment after class.

Contents of the stage	Activity	Tools	Competence
Tem work on task completion	step-by-step implementation of project tasks in each academic discipline (domain analysis, site development, project cost-performance calculation)	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	professional; integral; the ability to apply knowledge in practical situations
Evaluation of the quality of the task performed	evaluation of independently completed tasks; evaluation of tasks performed by other team members; refinement of tasks	GitHub; Bitbucked; DeployBot; Phabricator; BeanStalk; professionally-oriented software and services	ability to be critical and self-critical; the ability to evaluate and ensure the quality of work performed
Report generating on the work performed	generating a team work report on the project	Power Point Online; Sway	the ability to visualize, formulate, solve problematic situations, making the right decisions, taking into account available information
Presentation of results	report placement; evaluation	Miro	the ability to present the project to investors or your own team

preparatory, basic, and integrated. At the end of each project, student success levels were evaluated based on the proposed methodology.

To test the effectiveness of the cloud-oriented environment for inverted learning, a null hypothesis was formulated, assuming that there would be no significant difference in average learning scores between the control and experimental groups. The rejection of this hypothesis would indicate that the use of such an environment enhances student academic performance. The proposed statistical hypothesis was tested using a Student's t-test for independent samples. This test requires meeting two conditions: exceeding the minimum required sample size and equality of variances.

To determine if the sample size was sufficient for the t-test with a significance level of 0.05, a power of 80%, and a standard mean effect, an analysis was conducted. To estimate the sample size required for each of the two student samples (control and experimental) when applying this method, at least 64 people are needed.

To verify the second condition, a test for the equality of variances was performed. The calculations revealed that the probability of obtaining a type I error is 25.8% with a permissible 5% to reject the null hypothesis. Consequently, the variances are statistically equal, enabling the estimation of averages using the t-test.

The t-test results for the general averages in the two groups are presented below:

```
t.test(rating~group, data=Data, var.equal=TRUE)
##  Two Sample test
## data:  rating by group
## t = 7.7655, df = 670, p-value = 3.054e-14
## alternative hypothesis: true difference is means is not equal to 0
## 95 percent confidence interval:
##  4.804434 8.056249
## sample estimates:
## mean in group Experimental  mean in group Control
##                  79.90435                   73.47401
```

The t-test results indicate that the calculated t-value is 7.7655 with 670 degrees of freedom and a p-value of $3.054 \cdot 10^{-14}$. Since the p-value is less than the significance level of 0.05, we can reject the null hypothesis and conclude that there is a significant difference between the average learning scores of the control and experimental groups. The confidence interval for this difference lies between 4.804434 and 8.056249. The sample estimates for the mean learning scores in the experimental and control groups are 79.90435 and 73.47401, respectively.

Table 7 provides descriptive characteristics of the samples' grades (academic performances). The table includes data for the experimental and control groups, as well as the total average and difference between the groups.

Table 7
Descriptive characteristics of samples on grades.

Stage	Group		Total average	Difference
	Experimental	Control		
Stage 1	81.3	74.6	78.1	6.7
Stage 2	78.2	73.6	76	4.6
Stage 3	80.2	72.2	76.3	8
Total average	79.9	73.5	76.8	6.4

Comparing the total average scores, there is a difference of 6.4 points between the experimental and control groups. The largest difference is observed at the 3rd stage, with a difference of 8 points.

Analyzing the data, we can observe differences in medians and score distributions. The experimental group consistently shows better results both in terms of the overall score and scores at each stage (figure 7).

Based on the results, the Student t-test calculated using the experimental data exceeds the critical value of 7.77, which is greater than 1.967 for a given level of significance (0.05). This allows us to reject the null hypothesis of equality of the two means. Consequently, we can conclude that the difference between the average grades of the control and experimental groups (6.4 points) is statistically significant. With a probability of 95%, this difference will range from 4.8 to 8.1 points. Therefore, based on the results of the analysis of variance, we can infer that using a cloud-based environment for inverted learning of IT students has an impact on their academic achievements.

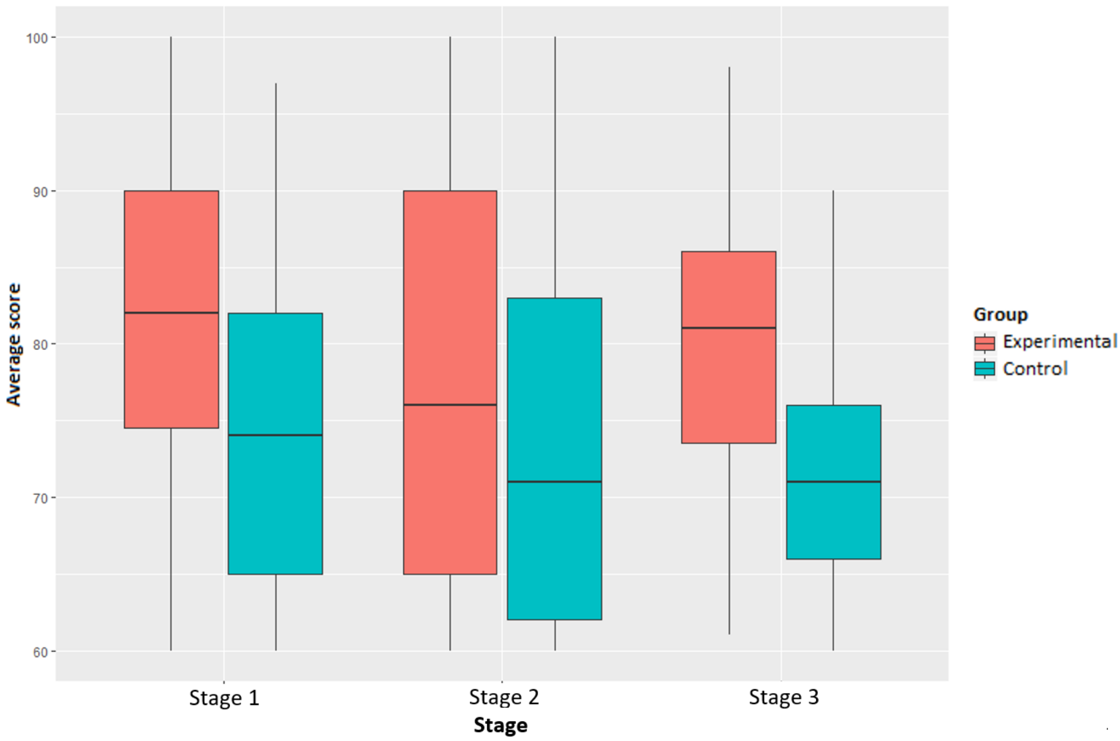

Figure 7: Box plot diagram of grades by stages and groups.

5. Conclusions

In the study that spanned 3 years, a cloud-based environment was employed to implement flipped learning projects in the education process of future IT specialists. The developed methodology is based on the use of services for project management and collective IT development during three activity stages: preparatory, basic, and integral.

One of the most important results obtained during the study was the identification of performance indicators for the developed cloud-based environment model. These indicators cover the functionality of the environment by 3 criteria: for professional activity, for the implementation of flipped learning technology, and for project management. The cloud-oriented environment of the university, designed on the basis of determined criteria and indicators, is the main component of the flipped learning system for training future IT professionals. The design of this cloud-oriented environment for project implementation enables teachers to choose the means available to complete project tasks, integrate necessary services and resources into the created environment, and facilitate communication between educators who teach project disciplines and teams of students. Students have the opportunity to effectively plan project implementation steps, distribute tasks among team members, monitor their implementation, and organize teamwork to create the end product of the project.

Procedures for using Microsoft Teams, GitHub, and Jira cloud services are developed on the basis of process models. These procedures make it possible to regulate these processes and provide effective use of the methodology at three stages.

In these stages, the necessary professional and personal skills were formed during the project tasks performing using the appropriate cloud resources and services of the university environment. During each of the stages students develop the ability to organize joint activities and form a capable team, the ability to form a communication system in a team, using appropriate cloud services, the ability to take control of the situation, the ability to unite a group and build an effective team interaction to solve certain tasks, etc.

As a result of pedagogical experiment the students' grades increased by 6.4 points, which is confirmed by the results of statistical processing of research results. The developed methodology can be used by higher education institutions for the implementation of project training in the education of future IT professionals.

In these stages, students develop the ability to organize joint activities and form a capable team, the ability to form a communication system in a team using appropriate cloud services, the ability to take control of the situation, the ability to unite a group and build effective team interaction to solve certain tasks, and more.

As a result of the pedagogical experiment, students' grades increased by 6.4 points, which is confirmed by the results of statistical processing of research results. The developed methodology can be used by higher education institutions for the implementation of project training in the education of future IT professionals.

6. Future work

This study has explored how a cloud-based environment can support flipped learning for future IT specialists. However, there are still many opportunities for further research and development, such as:

- Long-term impact analysis: how does flipped learning with a cloud-based environment affect students' academic performance, career paths, and professional growth in the long run? A longitudinal study could track graduates and measure their success in the IT industry.
- Adaptation to diverse disciplines: how can the cloud-based environment be adapted to different academic fields and domains beyond IT? A comparative study could examine the effectiveness of flipped learning with a cloud-based environment in various educational contexts.
- Technology evolution: how can the cloud-based environment keep up with the latest developments in cloud technologies and services? A continuous evaluation could ensure that the cloud-based environment meets the changing needs of educators and students. This could also involve testing new cloud platforms and tools.
- Assessment and feedback enhancement: how can the assessment methods and feedback mechanisms within the cloud-based environment be improved to provide more detailed insights into student progress and learning outcomes? An integration of AI-driven assessment and analytics tools could offer real-time feedback.

- Inclusivity and accessibility: how can the cloud-based environment be accessible to all students, regardless of their abilities or access to technology? An implementation of inclusive design principles could evaluate their impact on learning outcomes.
- Cross-institutional collaboration: how can the cloud-based environment facilitate collaboration with other educational institutions to create a shared ecosystem for flipped learning? A development of standardized tools and best practices could enable seamless collaboration.
- Faculty development: how can educators be trained to use the cloud-based environment effectively for flipped learning? A design and implementation of faculty development programs could investigate their impact on student outcomes.
- Ethical considerations: how can ethical issues related to data privacy, security, and the responsible use of AI and machine learning algorithms within the cloud-based environment be addressed? A development of guidelines and protocols could protect sensitive information.
- Student engagement: how can student engagement within the cloud-based environment be enhanced, using features such as gamification, personalized learning pathways, and peer-to-peer collaboration?
- Global application: how feasible is it to apply the methodology and cloud-based environment in international educational settings, considering cultural and linguistic diversity?

By pursuing these future directions, technology-enhanced education can continue to evolve, ensuring that future IT specialists and other professionals receive innovative and effective education.

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