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# PROJECT-BASED TRAINING FOR FUTURE IT PROFESSIONALS IN A DIGITAL EDUCATIONAL ENVIRONMENT BASED ON THE DEVOPS METHODOLOGY

**Abstract.** The article provides a theoretical basis for applying the DevOps methodology to project-based learning in higher education institutions' digital environments. The effectiveness of this approach has been verified through experimentation. The study's relevance is determined by the need to increase the practical orientation of student training. It is also important to prepare students for professional activity in the digital economy. This paper reveals the pedagogical potential of the DevOps methodology for practice-oriented learning. Particular attention is given to developing students' professional and team competencies. The DevOps methodology is presented as an integrative educational system. It incorporates the principles of an uninterrupted educational process, iterative project activities, automated routine educational operations, and systematic feedback. The article proposes a DevOps-based project-based learning model. This model involves organizing student team project activities in a digital educational environment. Learning management systems, cloud services, and collaboration platforms are used to this end. The model is implemented as an iterative cycle. This ensures transparency in the learning process. It also integrates individual and team activities. Particular attention is paid to supporting students' reflective activities. The effectiveness of the proposed model was tested through a pedagogical experiment. The study was conducted with bachelor's degree students. The results showed a statistically significant increase in professional, team, and reflective competencies among the experimental group. These indicators were higher than those of the control group. These results confirm the effectiveness of implementing DevOps-oriented, project-based learning using digital platforms and cloud services.
These results can be used to improve students' practical training in higher education institutions. The results also serve as a basis for developing methodological recommendations for implementing DevOps-oriented project-based learning in various fields of education.

**Keywords:** project-based learning; digital educational environments; DevOps; information and communication technologies

## 1. INTRODUCTION

**The problem statement**. The current stage of higher education development is characterized by significant transformations. These changes are driven by the digitization of socioeconomic processes. They are also linked to the growing importance of information and communication technologies. Another important factor is the changing demands of the labor market for professional training of specialists.

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Under these conditions, the primary responsibility of higher education institutions is to provide practical training. Students must be able to apply their knowledge to real professional situations. Students must also be prepared to work in interdisciplinary teams. Particular attention should be paid to their ability to adapt to the dynamic conditions of professional activity.

In this context, project-based learning is a particularly important approach to organizing the educational process. It is based on an activity-based approach. Project-based learning involves students actively participating in solving practical tasks. This approach promotes the integration of theoretical knowledge and practical activity. It also fosters critical thinking, communication, and accountability for group outcomes.

However, the effectiveness of project-based learning depends on having a clear methodological framework. This framework must ensure the integrity and consistency of the educational process. It should also guarantee manageability. This is particularly important in a digital educational environment.

A digital educational environment significantly expands the possibilities of project-based learning. Learning management systems play a key role in this expansion. Cloud services, collaboration platforms, and digital communication tools also play an important role. However, the fragmented use of individual digital tools often fails to deliver the expected educational results. This is due to a lack of a systematic approach to their use.

These circumstances necessitate methodologies that can integrate the technological, organizational, and pedagogical aspects of project activities. Such methodologies should ensure the formation of a unified, holistic learning model.

One promising methodology in this context is DevOps. Originally developed in the IT industry, DevOps is an approach that integrates the processes of developing, implementing, and supporting digital products. The main principles of DevOps are process continuity, iteration, and automation. Shared responsibility and systematic feedback are also important. These principles are interdisciplinary in nature. They can be adapted to the educational process.

In the pedagogical realm, DevOps is more than just a set of technological practices. It can also serve as a methodology for organizing collaborative efforts. This approach aligns with the principles of project-based learning in a digital environment.

Despite growing interest in implementing DevOps approaches in IT specialist training, several issues remain under-researched. In particular, this concerns their systematic pedagogical interpretation. The use of DevOps as a methodological basis for project-based learning in higher education has also not been sufficiently studied. This necessitates a theoretical understanding of DevOps' educational potential. Additionally, there is a need for experimental verification of the effectiveness of integrating DevOps into the educational process.

**Analysis of recent studies and publications.** Pedagogical science has accumulated considerable theoretical and practical experience in researching project-based learning. It is considered an effective means of developing students' professional, social, and interpersonal competencies [1]. Scientific works interpret project-based learning as a means of implementing activity- and competency-based approaches [2]. This approach ensures that students play an active role in the learning process. It also guides them toward creating a meaningful product. An important outcome is the development of responsibility for one's own actions [3-4].

Researchers emphasize that combining project activities with information and communication technology increases learning effectiveness. Learning management systems are one of the key factors in this process [5]. Cloud services and digital collaboration platforms also play a significant role. This list includes online communication tools. Using these tools increases students' motivation to learn. They also ensure the development of independent work and activity planning skills. An important result is the development of teamwork skills [6].

Some studies focus on the role of the digital educational environment [7-9]. This environment is seen as a space for integrating the formal and informal aspects of learning. Such an environment also ensures continuity in the educational process.

At the same time, an analysis of scientific sources reveals limitations in existing research. Most scientific works focus on the methodology of project-based learning. Some studies only describe individual digital tools. The issue of methodological integrity when organizing project activities in a digital environment is often overlooked. Using information and communication technologies in a fragmented manner, without a unified conceptual framework, does not ensure the systematic nature of the learning process. This also complicates the prediction of educational outcomes.

In scientific publications, the DevOps methodology is primarily considered in the context of the professional training of information technology specialists [12], [13], [14]. DevOps is interpreted as an approach to organizing processes for developing, testing, and implementing software products. Some studies analyze the educational potential of DevOps practices in IT specialist training [15], [16]. Issues of software engineering and IT project management are also addressed [17]. Nevertheless, DevOps is rarely interpreted as a general pedagogical methodology. Its potential for adaptation to a broader educational context remains largely unexplored.

The pedagogical interpretation of key DevOps principles has not been sufficiently researched. These principles include process continuity, cyclicity, automation, shared responsibility, and systematic feedback. The application of these principles to project-based learning in a digital educational environment requires additional scientific justification. There are few empirical studies on this topic in the scientific literature. There is insufficient data confirming the impact of a DevOps-oriented educational process on learning outcomes. In particular, little research has been conducted on the development of students' professional and team competencies.

Thus, an analysis of previous studies reveals a scientific gap. This gap exists between theoretically sound approaches to project-based learning and the capabilities of the digital educational environment. Additionally, the potential of the DevOps methodology as an integrative basis for organizing the educational process remains largely untapped. This underscores the need for further research. Such research should aim to improve the theoretical understanding of the DevOps approach and experimentally verify the effectiveness of implementing DevOps-oriented project-based learning in higher education.

**The research goal.** Theoretical justification of the effectiveness of project-based learning in a digital educational environment based on the DevOps methodology. An additional goal is to verify the approach's effectiveness through experimentation. The study identifies the pedagogical conditions necessary for its successful implementation in higher education.

## 2. RESEARCH METHODS

The study's methodology is based on activity-, systemic-, and competency-based approaches. Together, they provide a comprehensive understanding of project-based learning processes in a digital educational environment.

The activity-based approach allows us to view learning as an active process. It involves students performing practical tasks. These tasks aim to achieve specific results within project activities.

The systemic approach analyzes the educational process as a holistic, dynamic system. In this system, learning goals interact. The content, methods, and means of learning are also interrelated. An important component is the results of participants' activities in the educational process.

The competency-based approach focuses research on assessing learning outcomes. The main focus is on the development level of learners' professional and interpersonal competencies. These competencies are considered an integral outcome of the educational process.

A set of general scientific and pedagogical methods was employed in the research process. Theoretical analysis was employed to study scientific sources. The analysis covered project-based learning, the digital educational environment, and the DevOps methodology. Generalization was employed to determine the conceptual basis of the research.

A project-based learning model was developed using the pedagogical modeling method. This model is designed to function in a digital educational environment. It is based on the DevOps methodology.

Empirical methods included pedagogical observations and student surveys. The results of the project activities were also analyzed. Expert assessment was used to evaluate the level of professional competence development.

Traditional tools were used to collect empirical data. Additionally, digital educational environment tools were used. Particular attention was paid to analyzing digital traces of students' learning activities. These traces were recorded in learning management systems and on collaboration platforms.

A pedagogical experiment was conducted to test the effectiveness of the proposed model. The experiment included ascertaining and formative stages.

The results of the experiment were statistically processed. Descriptive statistics and comparative analysis methods were used for this purpose. This allowed us to identify the dynamics of changes in students' competence development levels in the control and experimental groups.

The study considers the DevOps methodology as an integrative educational approach. It transcends a purely technical interpretation. DevOps is understood as a set of principles that organize the collaborative efforts of those involved in the educational process. These principles ensure the continuity of these processes. They also account for the iterative nature of task execution. Integrating roles and responsibilities and automating routine operations are important. Systemic feedback also plays a significant role.

This interpretation enables the adaptation of DevOps principles to the pedagogical context. It also establishes them as a methodological basis for organizing project-based learning in a digital educational environment.

Thus, the chosen research methodology ensures the scientific validity of the obtained results. It guarantees their reproducibility. The methodology also creates opportunities for the proposed model to be further implemented in higher education practice.

## 3. THE RESULTS AND DISCUSSION

### 3.1. Project-based learning model based on DevOps principles

The proposed project-based learning model is based on the principles of the DevOps methodology. These principles are integrated into the organization of the educational pedagogy. The model promotes the systematic use of a digital learning environment. This environment is considered a space for students' project activities.

This environment is interpreted as a set of interrelated components. These include learning management systems. Cloud services and collaboration platforms are also important components. Digital communication tools play a separate role. Together, these components ensure the integrity and transparency of the educational process.

Within the model, the educational process is implemented through iterative cycles. These cycles align with DevOps' logic. They are adapted to the pedagogical context. Each cycle covers the planning stage of project tasks. Next, the planned actions are implemented. This is followed by an assessment of interim results. The final stage is reflection. This organization ensures continuity of learning. It also enables quick adjustments to activities.

The iterative nature of project work helps students develop self-organization skills. It also helps them hone their planning abilities. An important outcome is that students take on more responsibility for their own work and that of their teams.

A key component of the model is combining individual and team work. Projects involve a clear division of roles. This allows each participant to understand their contribution to the overall outcome. This approach promotes the development of teamwork skills.

Using digital project management and collaboration tools ensures transparency of processes. These tools allow for monitoring of task completion. Data on students' learning activities is also accumulated.

Figure 1 presents a structural diagram that clearly captures the key characteristics of a DevOps-oriented model of project-based learning in a digital educational environment. The diagram reflects the relationship between the model's basic principles and the expected educational outcomes.

Figure 1 presents a structural diagram of the DevOps-oriented project-based learning model. The diagram illustrates the model's main characteristics and the mechanisms for implementing it in a digital educational environment. The central element of the model is project-based learning. It is based on the principles of DevOps. This approach ensures the systematic organization of students' learning activities.

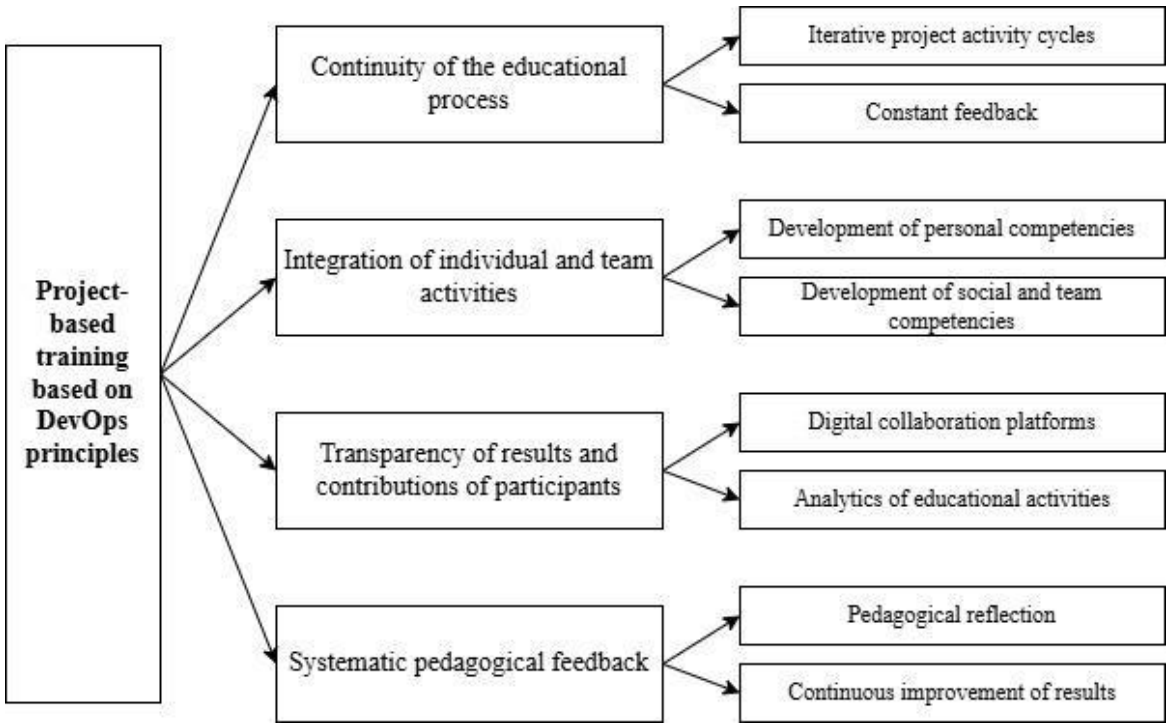


*Fig. 1. Key characteristics of the DevOps-oriented project-based learning model*

The diagram illustrates the model's four key characteristics. The educational process is continuous through iterative cycles of project activity. Constant feedback is an important element. This ensures gradual improvement in learning outcomes.

Simultaneously integrating individual and team activities develops students' personal competencies. It also fosters the development of social and team skills.

Digital collaboration platforms provide transparency into each participant’s results and contributions. Additionally, learning analytics are applied. This allows for an objective assessment of project activity results.

Systematic pedagogical feedback supports students' reflective activities. This feedback focuses the learning process on continuous improvement of educational outcomes.

The presented diagram summarizes the conceptual provisions of the proposed model. The diagram serves as the basis for the model's practical implementation in project-based learning processes at higher education institutions.

Teachers play a special role in implementing this model. Their role shifts from traditional knowledge transmitters to facilitators and mentors. Teachers coordinate students' project activities. They provide methodological support for the learning process. Teachers also provide timely feedback. They pay special attention to creating conditions that encourage students to reflect. This transformation of the teacher's role aligns with modern ideas about pedagogical interaction in a digital educational environment. This contributes to students' professional growth.

The proposed model ensures the methodological integrity of project-based learning. It harmonizes the pedagogical and technological components of the educational process. The model establishes the foundation for developing students' professional and team competencies. These competencies are necessary for success in the digital economy.

### 3.2. Training project within the DevOps-oriented model of project-based learning

A training project was developed to implement the project-based learning model using the DevOps methodology. The project focused on modeling real professional processes in a digital environment. It was implemented within the “Deployment of Information Systems” discipline. The project involved teamwork among students. The goal was to create and gradually improve a digital service.

The project aimed to develop students' ability to plan project activities. The project also aimed to develop students' skills in implementing and evaluating project results. Modern digital tools were used for this purpose. Another important objective was to foster professional and team competencies in accordance with DevOps principles. The project's objective was to develop a functional prototype of a web service. Cloud infrastructure was used for this purpose. Version control, automated deployment, and collaboration tools were also used.

The learning process was organized using the Moodle learning management system. Moodle served as the central element of the digital educational environment, providing access to learning materials. Moodle provided access to learning materials. Through the system, students received project assignments and assessment criteria. Moodle also recorded the reflection results.

Trello and Jira are task management tools that were used to plan project activities. They were also used to manage iterations. These tools enabled us to organize the project's stages. They also facilitated role distribution within the team. One important feature was the transparency of task execution.

We carried out team product development using Git version control. We used GitHub repositories for this purpose. These repositories ensured collaborative work on the code. GitHub allowed them to record changes and control versions. It was also possible to analyze each team member's contribution.

We used continuous integration and delivery tools to automate the testing and deployment of the prototype. These tools were implemented based on GitHub Actions. These tools were adapted for educational use.

The digital service was deployed on Amazon Web Services or Microsoft Azure. This enabled students to simulate real-world operating conditions for information systems. Docker tools were used for containerization. These tools ensured the reproducibility of the deployment environment. The tools also simplified the integration of individual project components.

Team activities were communicated and coordinated via digital channels. Both synchronous and asynchronous communication tools were used. These included Microsoft Teams and Slack. Using these tools helped foster a culture of open communication. They also ensured rapid information exchange and joint decision-making.

The analysis of students' learning activities was based on data from the learning management system. Additionally, activity logs from repositories were used. Data from project management tools was also analyzed. These methods ensured an objective assessment of each team member's contribution.

Table 1 summarizes the digital tools used in the educational project. The table shows the correspondence between the tools, their functional purpose, and the competencies developed by students.

*Table 1*

**Correspondence between the digital tools used, project activity functions, and students' acquired competencies**

| Tool | Main function in the educational project | Competencies |
|---|---|---|
| Moodle | Organization of a digital educational environment, access to tasks and results | Self-organization, digital literacy, reflection |
| Trello / Jira | Iteration planning, task management | Project thinking, responsibility |
| Git | Version control, change tracking | Professional IT competencies |
| GitHub | Collaborative development, transparency of contributions | Teamwork, digital communication |
| GitHub Actions | Automation of testing and deployment | Systems thinking, continuous improvement |
| Docker | Containerization of the environment | Engineering thinking, adaptability |
| AWS / Microsoft Azure | Cloud deployment of the service | Infrastructure competencies |
| Microsoft Teams / Slack | Team communication | Communication and social competencies |
| Аналітика LMS і GitHub | Activity monitoring and feedback | Reflective competency |

The educational project was implemented in several iterations. Each iteration followed the DevOps cycle. This cycle included the stages of planning, development, testing, deployment, and analyzing the results.

At the end of each iteration, a reflection period was held. This evaluation aimed to assess the effectiveness of the tools used. Particular attention was paid to the quality of team interaction. Directions for improving the digital product were also identified.

The results of the training project were evaluated according to a set of criteria. These included the quality of the final product. The level of professional skill in working with DevOps tools was also assessed. The effectiveness of team interaction was also considered. Another indicator was the students' ability to self-assess and reflect.

The results confirmed the effectiveness of the proposed approach. Using specific digital tools in a DevOps-oriented, project-based learning model improved students' practical training. This approach also ensured students developed a holistic view of modern professional activity in the digital environment.

### 3.3. Organization and Conduct of the Pedagogical Experiment

The pedagogical experiment was conducted over one academic semester. The research took place at a technical higher education institution. The experiment aimed to test the effectiveness of implementing project-based learning in a digital educational environment. Training was organized based on the DevOps methodology.

Sixty-four first-level (bachelor's) higher education students participated in the study. All participants studied the F6 specialty, "Information Systems and Technologies."

At the beginning of the experiment, the participants were selected. Then, they were divided into a control group and an experimental group. The students' prior training levels were considered during the division. The results of the initial assessment were also considered. This ensured the groups were comparable. This approach contributed to the objectivity of the subsequent analysis.

The first stage of the experiment involved determining the students' initial level of professional competencies. The assessment was carried out according to predefined criteria.

The control group's learning process was organized using traditional project-based learning methods. This included classroom lessons and project tasks. Information and communication technologies were used to a limited extent. Digital tools were not systematically integrated across all stages of the project. The main focus was on the project's final outcome. Intermediate stages of implementation and reflection were sporadic.

In the experimental group, training was carried out according to the DevOps-oriented model of project-based learning that was developed. Digital platforms were actively used in the learning process. Cloud services and collaboration tools were also used. Students' project activities were organized into iterative cycles. Tasks were clearly and consistently planned. Interim results were regularly assessed. Systematic feedback was an important element. This approach ensured continuity in the learning process. It also contributed to transparency regarding the participants' activities. Students had the opportunity to quickly adjust their learning activities.

A system of criteria was developed to evaluate learning outcomes and assess professional competencies. These criteria reflected various aspects of students' learning activities. The cognitive criterion characterized the level of theoretical knowledge acquisition. It also reflected an understanding of the fundamentals of digital and project processes. The activity criterion determined students' ability to apply knowledge and skills to practical project activities. The communication criterion was related to the effectiveness of team interaction. This criterion covered digital communication and joint decision-making. The reflective criterion characterized students' ability to analyze the results of their activities. This criterion also reflected the ability to evaluate goal achievement and identify areas for improvement.

To diagnose the level at which the specified criteria were formed, a student questionnaire was used. The questionnaire was based on a self-assessment scale.

The cognitive criterion was assessed using a questionnaire. The questions aimed to identify the level at which students understood the theoretical foundations of project-based

learning. Particular attention was paid to the principles of its implementation in a digital educational environment. Students were asked to rate their level of agreement with the statement, "I understand the theoretical foundations of project-based learning and the principles of its implementation in a digital educational environment." The statement "I understand the logic of iterative project organization and its connection to the DevOps methodology" was also used.

The activity criterion was assessed using a different set of questionnaire questions. These questions reflected the students' ability to apply their knowledge and skills to practical project activities. The questionnaire included statements such as "I can independently plan the implementation of project tasks in a digital environment" and "I can effectively use digital platforms and cloud services to implement educational projects."

Special questions were used to determine the level of development of the communication criterion. These questions assessed students' teamwork effectiveness. The quality of digital communication during project implementation was assessed separately. Examples of these statements include "I interact effectively with team members during the implementation of an educational project" and "I use digital means of communication to discuss tasks and make joint decisions".

The reflective criterion was evaluated using a questionnaire. These questions reflected the students' ability to analyze the results of their activities. Their ability to identify areas for improvement was also assessed. Students were asked to evaluate the statement, "I regularly analyze the results of my activities during the implementation of an educational project." The statement "I take into account the feedback received to improve the results of my activities" was also used.

The questionnaire data were summarized for each criterion. This summary was then used in conjunction with the results of pedagogical observation. Expert assessment was also involved. Additionally, digital traces of students' learning activities were analyzed. This approach ensured the objectivity and reliability of the pedagogical experiment results.

The data obtained during the experiment served as the basis for further statistical analysis. The data were also used to analyze the effectiveness of implementing DevOps-oriented, project-based learning in a digital educational environment.

### 3.4. Experiment Results

The results of the pedagogical experiment were analyzed by comparing the indicators of the control and experimental groups. This comparison was conducted during the ascertaining and formative stages of the study. The analysis was conducted in accordance with specific criteria for the development of professional competencies. These criteria included cognitive, activity, communicative, and reflective components.

Initially, the level of development of students' professional competencies was assessed. This assessment covered students from both groups. The generalized results are presented in Table 2.

*Table 2*

**Levels of professional competence development among students at the ascertaining stage (%)**

| Level | Control group | Experimental group |
|---|---|---|
| Low | 34,6 | 33,8 |
| Medium | 46,2 | 47,1 |
| High | 19,2 | 19,1 |

The obtained data indicate that there were no statistically significant differences between the groups at the beginning of the experiment. These results confirm the comparability of the control and experimental groups. These results ensure the validity of the subsequent analysis.

After completing the formative stage, however, significant differences were recorded. These differences were related to the levels of development of students' professional competencies. The generalized results are presented in Table 3.

*Table 3*

**Levels of professional competence development among students after completion of the experiment (%)**

| Level | Control group | Experimental group |
|---|---|---|
| Low | 26,9 | 12,4 |
| Medium | 48,1 | 41,3 |
| High | 25,0 | 46,3 |

As shown in Table 3, the proportion of students with a high level of professional competence increased in the experimental group. The number of students with a low level of competence decreased as well. These changes are significant.

Positive dynamics were also observed in the control group. However, they were less pronounced.

To perform a more detailed analysis, the average values of the competence development indicators were determined. Calculations were performed for each criterion. The summarized results are presented in Table 4.

*Table 4*

**Average values of competency development indicators according to criteria (5-point scale)**

| Criterion | Control group | Experimental group |
|---|---|---|
| Cognitive | 3,6 | 4,1 |
| Activity-based | 3,4 | 4,4 |
| Communicative | 3,5 | 4,5 |
| Reflective | 3,2 | 4,3 |

The most significant differences between the groups are observed in terms of activity and communication criteria. These differences are directly related to the peculiarities of DevOps-oriented project management. Teamwork, cyclicity and systematic feedback are important factors.

The experimental group also showed a significant increase in reflective criterion scores. This indicates the development of students' self-assessment skills. There was also an increase in the level of analysis of their own activity results.

Pearson's chi-squared ($\chi^2$) test was used to determine the statistical significance of the differences between the control and experimental groups' results. The calculations showed that the empirical value of $\chi^2$ exceeded the critical value. The significance level was $p \leq 0.05$. These results suggest that introducing a DevOps-oriented model of project-based learning has a statistically significant impact on student learning outcomes.

Thus, the pedagogical experiment results confirmed the effectiveness of the proposed approach. Integrating DevOps methodology into project-based learning in a digital educational environment increases students' professional competencies. A particularly pronounced effect was recorded in the development of practical skills. High results were also achieved in team

interaction and reflective activity. These results confirm the feasibility of using DevOps as a methodological basis for organizing project-based learning in higher education.

## 4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The study demonstrated the feasibility of effectively adapting the DevOps methodology to a pedagogical context. DevOps can serve as a conceptual basis for organizing project-based learning in higher education institutions' digital educational environments.

A pedagogical interpretation of the DevOps methodology was conducted. This interpretation considers DevOps not only as a set of technical practices. Rather, DevOps is interpreted as an integrative educational methodology. This approach focuses on the continuity of the learning process. It involves iterative activities, team interaction, development, and the use of systematic feedback.

The proposed DevOps-oriented model of project-based learning coordinates the pedagogical components of the educational process. It integrates organizational and technological components of learning. The model improves the quality of practice-oriented student training.

The results of the pedagogical experiment confirmed the effectiveness of implementing this model. It has been established that the model positively impacts the development of professional and team competencies of higher education seekers. In particular, students' teamwork skills have improved. Their joint decision-making skills have improved. Students have developed the ability to analyze performance results and reflect on them. The generalized results are presented in Table 5.

*Table 5*

**The impact of the DevOps-oriented model on the components of students' professional competencies**

| Competency component | Manifestation in the control group | Manifestation in the experimental group |
|---|---|---|
| Cognitive | Acquisition of theoretical knowledge | Conscious application of knowledge in project activities |
| Activity-based | Completion of individual tasks | Systematic implementation of projects in iterative mode |
| Communicative | Episodic team interaction | Strong culture of teamwork |
| Reflective | Limited self-assessment of results | Regular reflection and correction of activities |

The data in Table 5 show the positive impact of an organization’s DevOps approach on the educational process. This impact is comprehensive in nature. It covers all components of students' professional competencies.

The study's practical significance lies in the possibility of implementing the proposed project-based learning model in higher education institutions of various profiles. The results can be used to modernize academic disciplines. This modernization aims to strengthen the practical component of education. The results can also be applied to prepare students to work in digital teams. The results are useful for developing readiness for interdisciplinary interaction. These results are particularly important for developing educational programs. These programs must meet the requirements of the digital economy and the modern labor market.

Further research prospects include expanding the experimental base. This involves including students from different fields of study and educational levels. One important direction

is to refine the tools used to evaluate the outcomes of DevOps-oriented, project-based learning. Standardizing these tools is also necessary. Special attention should be paid to researching the long-term impact of the proposed model. This refers to its impact on graduates' professional trajectories. A promising approach is to develop methodological recommendations. These recommendations should aim to introduce DevOps-oriented project-based learning in various fields of higher education.

The study's results confirm the scientific feasibility of integrating DevOps into project-based learning. The results also demonstrate its practical effectiveness in a digital educational environment. The obtained results outline promising directions for further developing this approach in higher education.

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# ПРОЄКТНЕ НАВЧАННЯ МАЙБУТНІХ ІТ-ФАХІВЦІВ У ЦИФРОВОМУ ОСВІТНЬОМУ СЕРЕДОВИЩІ НА ЗАСАДАХ МЕТОДОЛОГІЇ DEVOPS

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**Анотація.** У статті теоретично обґрунтовано доцільність застосування методології DevOps як концептуальної основи для реалізації проєктного навчання у цифровому освітньому середовищі закладів вищої освіти. Також експериментально перевірено ефективність такого підходу. Актуальність дослідження зумовлена потребою підвищення практичної спрямованості підготовки здобувачів освіти. Важливим є також формування їхньої готовності до професійної діяльності в умовах цифрової економіки.

У роботі розкрито педагогічний потенціал методології DevOps у контексті практикоорієнтованого навчання. Особливу увагу приділено формуванню професійних і командних компетентностей студентів. Методологію DevOps інтерпретовано як інтегративну освітню систему. Вона поєднує принципи безперервності навчального процесу, ітеративності проєктної діяльності, автоматизації рутинних освітніх операцій і системного зворотного зв’язку. У статті запропоновано модель проєктного навчання на засадах DevOps. Модель передбачає організацію командної проєктної діяльності студентів у цифровому освітньому середовищі. Для цього використовуються системи управління навчанням, хмарні сервіси та платформи спільної роботи. Реалізація моделі відбувається у формі ітеративних циклів. Це забезпечує прозорість навчального процесу. Також досягається інтеграція індивідуальної та командної діяльності. Окрему увагу приділено підтримці рефлексивної активності студентів. Ефективність запропонованої моделі перевірено в ході педагогічного експерименту. Дослідження проводилось серед студентів бакалаврського рівня. Результати експерименту засвідчили статистично значуще підвищення рівня сформованості професійних, командних і рефлексивних компетентностей у студентів експериментальної групи. Ці показники були вищими порівняно з контрольною групою. Це підтверджує результативність упровадження DevOps-орієнтованого проєктного навчання з використанням цифрових платформ і хмарних сервісів. Отримані результати можуть бути використані для вдосконалення практикоорієнтованої підготовки студентів у закладах вищої освіти. Вони також є підґрунтям для розроблення методичних рекомендацій щодо впровадження DevOps-орієнтованого проєктного навчання в різних галузях освіти.

**Ключові слова:** проєктне навчання; цифрове освітнє середовище; DevOps; інформаційно-комунікаційні технології

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