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Effectiveness of project-based learning with cloud tools for developing professional competencies in IT education

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In accordance with the requirements of the IT sector, higher education is aimed at training IT specialists with relevant hard and soft skills competencies. This study examines the possibility of integrating Project-Based Learning (PBL) into training of IT students to develop programming, project and teamwork skills using professional cloud services and tools in IT project work. The selection of relevant cloud tools for project work was carried out by an expert group of teachers and IT specialists. The proposed approach was applied when studying programming courses at the Karaganda Buketov University. The students of the experimental group studied using PBL and professional cloud tools to work on the project, depending on the tasks and type of project. Pre- and post-testing were used for quantitative analysis, and surveys were conducted for qualitative analysis to assess students' programming skills, project activities, and teamwork before and after the experiment. The experimental group showed positive results in statistical data analysis, which indicates the effectiveness of the methods used. Based on the obtained experimental data and analysis of existing scientific works, conclusions were made confirming the relevance and effectiveness of the implementation of PBL with cloud services in the educational process in IT disciplines in higher education.

KEYWORDS

project-based learning (PBL), cloud services, IT education, professional competencies, soft skills, competency-based approach

1 Introduction

The digital transformation of education plays a key role in training high-demand IT professionals. Modern education is increasingly using digital technologies to meet the demands of the labor market. Future IT professionals need not only basic knowledge and standard skills, but also special thinking, deep knowledge of programming languages and the ability to make non-standard solutions (Yu et al., 2016).

Students' professional competencies are formed as a result of a properly organized educational process, which will be aimed at developing communication skills, students' abilities to carry out complex real IT projects, the ability to work in a team, manage projects, critical thinking, etc. (Wang, 2023). Students receive complex tasks that are close to the real tasks of the IT field mainly during the preparation of the final qualification project. However, one qualification project is not enough to master project skills (Kovalevskaia et al., 2021). Therefore, IT students should carry out real projects on the development of software applications already within the framework of specialized disciplines using appropriate pedagogical approaches.

PBL is widely used in engineering and science education, promoting collaboration, problem solving, critical thinking, and student engagement (Chen et al., 2021; Afanasiev et al., 2021; Rehman et al., 2024; Dai et al., 2025). In the context of digitalization, research highlights the importance of integrating digital tools with PBL. Research confirms the potential of GenAI chatbots to support project work (Perifanou and Economides, 2025), MOOCs to promote teamwork and responsibility (Spirina et al., 2024), and web-based tools to enhance creativity and learning outcomes (Marini et al., 2025). Cloud technologies are widely used in e-learning, distance and hybrid education, as well as to create LMS in higher education (Kovalevskaia et al., 2021; Dema and Choden, 2024; Rijal et al., 2024; Grover and Nandal, 2024). Combining PBL with cloud solutions shows positive results: Tang et al. (2023) reported improved software application and critical thinking skills when using cloud-based LMS, while Srikan et al. (2021) demonstrated increased creativity and digital media skills in PBL with cloud support.

The use of professional IT tools, including cloud services, used in the development, testing, deployment and management of IT projects as part of the study of specialized disciplines of the computer cycle, allows you to shift the focus in the learning process from purely educational activities to solving professional problems using tools used in professional communities, in software development teams (Rochev and Semyashkina, 2023). For students of the IT field, project work and cloud services, on the one hand, are the subject of study in order to master them at a professional level, on the other hand, they are a means or tool that allows them to solve related tasks in software development in their professional activities.

The purpose of this study is to evaluate the effectiveness of project-based IT training for students in teaching specialized disciplines in learning programming languages using professional cloud services.

To achieve this goal, the following Research Tasks were solved in the study:

1. To conduct a comparative analysis of the academic results of students who studied programming languages using the traditional methodology, and students who studied using the PBL approach using professional cloud tools;
2. To assess the impact of PBL on the formation of professional and personal competencies of IT students, such as motivation, project work skills and teamwork.

2 Literature review

Project-based learning (PBL) is a pedagogical strategy based on independent planning and solving complex practical tasks through the implementation of real projects (Thomas, 2000). The ideas of the project method were first substantiated by J. Dewey and W. Kilpatrick in the early twentieth century (Kilpatric, 1918).

Many authors agree that PBL is especially suitable for engineering students to prepare for their future professions. Thus, Teixeira et al. (2020) note that "PBL's approach to teaching and learning increases students' ability to acquire and apply knowledge in real professional situations, preparing them to master the necessary competencies that meet the modern requirements of both companies and academia."

In the study by O'Connor et al. (2024), when exploring the possibility of using online PBL in engineering education, the factors that teachers should consider were identified, namely: communication, module planning, student relationships and team structure, flexibility of the online environment.

Based on a meta-analysis of 66 studies by Zhang and Ma (2023), they proved that project-based learning is significantly superior to traditional methods, especially in engineering and technology disciplines and in practical classes. The effectiveness of the method varies depending on the subject area, the type of course, the duration of the experiment, and the size of the study group.

PBL as a practical teaching method has positive application results in various fields: medicine (Kldiashvili et al., 2025), in the study of foreign languages (Ghosheh Wahbeh et al., 2021), in teaching physics (Gao and Yang, 2023), computer science (Almulla, 2020; Sindre et al., 2018). The results showed that the introduction of PBL increased student motivation and improved skills.

PBL is effectively applied in face-to-face, online, hybrid and hybrid/blended learning, often combined with digital technologies (Dahham and Fawareh, 2022). Studies highlight successful implementations in IT education use of PBL, for example, in a hybrid learning environment for software engineering (Ceh Varela et al., 2023), Mobile-PBL (Al-Qora'n et al., 2023), Blended Project Learning (BPBL) includes a mixture of face-to-face and online components (Adri et al., 2020; Barbosa, 2022).

Many studies confirm the high potential of PBL and digital technologies in teaching IT disciplines. PBL provides real-world problem solving experience, develops students' practical, cognitive, and communication skills (Alves et al., 2018; Saad, 2022; Guo et al., 2020), and is successfully combined with other forms of learning and digital tools (Lescano and Yamao, 2023; Naik and Girase, 2021).

As noted by Bogdan et al. (2019), the relevance of cloud technologies in education is confirmed by their ability to provide a high degree of interactivity, accessibility of educational materials and the ability to work together on projects and assignments. Cloud technologies facilitate planning, collaboration and communication, as well as support individual learning in project activities (Çakiroğlu and Erdemir, 2018).

Some professional cloud services in the preparation of IT students were considered by Omelchenko and Omelchenko (2021), who presented the experience of using 1C cloud services; Rochev and Semyashkina (2023) considered the possibilities of using cloud-based software version control tools. Authors, Marnewick (2023), Bryzgalova (2021), Suswanto et al. (2017), note that professional cloud services have extensive capabilities and many of them can be used in various specialized disciplines of the computer cycle to solve IT tasks close to real projects.

At the same time, according to the recommendations for career growth in IT the relevance of using cloud services in the specialized training of IT students is justified by key factors of the IT industry (Rawat, 2024; Ohiri, 2023):

1. Technological progress. Preparing students to work with cloud services is becoming mandatory for a successful career in IT.
2. Labor market needs. Employers expect university graduates to be familiar and proficient with such technologies.
3. Flexibility and efficiency. Cloud services provide flexibility and scalability, allowing students easy access to resources and tools from anywhere in the world.

4. Collaborative opportunities. Many cloud platforms provide collaboration and team collaboration capabilities.

In general, the use of cloud services in the profile training of IT students not only corresponds to current trends in the IT industry, but also allows improving the quality of education, preparing students for real tasks and the needs of the labor market.

PBL has proven to be an effective approach to the formation of students' competencies, and its integration with digital technologies enhances the educational effect. However, there is insufficient research examining the use of professional cloud services in project-based programming training, which determines the need for further study of their effectiveness in training IT specialists.

3 Research method

The study used theoretical methods (literature analysis, comparison of researchers' opinions on the use of PBL, the use of cloud services in student education, generalization and systematization of theoretical material on the problem under study) and empirical research methods (student surveys, conversations with students and teachers, analysis of experimental research results). The main tools for obtaining quantitative data were the results pre- and post-testing, which was conducted to solve Research Task 1. The results were evaluated according to the scale of the European Credit Transfer and Accumulation System (ECTS). To obtain qualitative results, the survey data was compared before and after the experiment were compared to solve Research Task 2. The Likert scale was used to evaluate the questionnaire questions.

The study took place in several stages:

Stage 1—pre-test to identify the initial level of students and conduct an introductory survey to identify students' attitudes to PBL when learning programming, as well as identifying professional cloud platforms and services for learning programming languages, developing methodological recommendations on the use of cloud tools when performing an IT project within the discipline;

Stage 2—experiment with the use of PBL methods and the implementation of project work with cloud tools by students;

Stage 3 is a post–test to determine the level of students after completing the experiment and conducting a post-survey to identify students' attitudes towards PBL with cloud tools when learning programming;

Stage 4—processing and analysis of experimental results.

The Expert Group was established to develop project-based training, identify relevant IT professional cloud services, and prepare test assignments for pre- and post-testing. The Expert Group included 5 graduates of the department working in IT companies and 12 teachers.

The study involved third-year students of the educational program "Information Systems" of the E. A. Buketov Karaganda University of the Republic of Kazakhstan. The participants have a basic knowledge of programming technology, which allowed them to freely participate in the study. To assess the effectiveness of the PBL methodology on learning outcomes, students (43 students in total) were randomly divided into control ($N = 21$) and experimental groups ($N = 22$). The sample was gender diverse, including 29 male and 14 female students. The experiment was conducted during one semester.

The content of the academic disciplines "Programming in Python" and "Programming in Java," covered by both groups, was the same in terms of volume and sequence of academic topics, however, the way classes were conducted and the level of active student involvement differed significantly. The control group (CG) studied using a traditional approach: they studied theoretical material, reviewed and programmed training examples, discussed various approaches to solving problems under the guidance of a teacher, and could optionally use cloud services as a tool for solving learning tasks, but did not complete the final project work.

In contrast, the students of the experimental group (EG) gained knowledge through the application of PBL, namely, they completed the final IT project during the last 6 weeks of the semester. Moreover, they used cloud services recommended by the teachers, depending on the tasks and the type of project. The implementation of an IT project consists in creating a unique software application or system that is as close as possible to the real one, fulfills a number of functional requirements and meets the specific needs of users.

Pre- and post-tests were conducted to conduct a comparative analysis of the academic results of CG students who studied programming languages using the traditional methodology, and EG students who studied using the PBL approach using professional cloud tools (Research Task 1). The test tasks were developed taking into account Bloom's taxonomy in order to cover several cognitive levels from basic memorization to analytical thinking. According to the recommendations of Gosen and Washbush (2004), assessment tools should be consistent with the results of experimental training to ensure validity and reliability.

The developed tests consisted of 25 multiple-choice questions in accordance with Bloom's cognitive complexity matrix and are aimed at assessing the developed skills of application and analysis of program code. In addition, questions at the "assessment" level are included, allowing you to evaluate the proposed code fragments, find an error, or select the correct code instructions, which allows you to develop critical thinking skills. Cognitive processes for the "creation" level of goals are implemented by students during the application of the project-oriented learning approach, especially actively when students independently or in a team work on an IT project. Academic results were assessed using the ECTS. The assessment of the reliability of measurement instruments was verified using the Cronbach's alpha coefficient with similar student groups, the result is $\alpha = 0.82$, which confirms good internal consistency. The obtained correlation coefficient $r = 0.73$ confirms the ability of grades to reflect a positive change in students' results.

To assess the impact of PBL on the development of soft skills competencies of IT students (Research Task 2), a survey was conducted CG and EG using a questionnaire developed by an expert group in the Google Forms format.

During the study, the students of the CG and EG passed the same preliminary test and an online survey to determine the initial level of knowledge and assess confidence in the implementation of the IT project, then at the end of the semester after the experiment, they passed the same post-test to measure differences in the acquisition of knowledge, understanding and practical skills in software development, as well as a post-survey to assess the impact of PBL on the development of students' personal professional competencies, in particular motivation, project work skills and teamwork skills. These measurements allowed for a comparative analysis of experimental

learning for knowledge gain. To analyze the quantitative data, the Student's t-test was used to compare the deviations of the average values of the pre- and post-test results in the control and experimental groups.

4 Results and discussion

At the first stage of the study, the expert group identified IT professional cloud services that are used by professional programmers. The choice of a specific platform depends on the specifics of the discipline, the goals of the IT project, the specifics of the tasks and preferences. The survey results are presented in Table 1.

These IT professional cloud services were recommended to students when doing project work. The teacher issues the assignment for the project and the allocation of students to projects (i.e., the formation of a project subgroup) in the first weeks of the semester. The project involves the creation of software (applications, software products) close to the real tasks of the IT sector. Then students assign roles in the project, divide the project into tasks and modules, determine the deadlines for the implementation of modules, a prototype, a project, deadlines for the presentation and protection of the project. As noted by Çakiroğlu and Erdemir (2018), the teacher, organizing project training, acquires special powers, he acts as a facilitator or coach, provides assistance in difficult situations and guides in choosing the best solutions and cloud services for this project. As part of the study, it turned out that psychological problems may arise when communicating with students, which can negatively affect the results of the project, which was noted by Bryzgalova (2021) and Rijal et al. (2024).

Table 2 shows the contents of a questionnaire for students' self-assessment of programming skills, project activities, and teamwork, which was used before and after the experiment. The questionnaire includes questions to determine students' interest in PBL using cloud services when studying specialized programming disciplines, as well as questions to identify students' self-esteem for joint IT projects and willingness to work in a team. The Likert scale was used to evaluate the questionnaire questions (1—very low, 5—very high).

Table 3 shows the results of responses to a questionnaire to identify students' self-esteem in the form of average scores on the Likert scale, standard deviation (SD) for the CG and EG groups for each question of the survey conducted before the experiment (pre-survey) and after the experiment (post-survey).

An analysis of the results of the pre-survey allows us to conclude that students in the control and experimental groups rate their programming skills rather low and have little understanding of the specifics of creating a real IT project (questions Q1, Q2).

Questions Q3–Q4 assessed students' confidence in developing an IT project. Before the experiment, most people believed that project work only applies existing knowledge. However, the post-survey showed an increase in self-assessment of programming skills in EG (from 2.76 to 3.73 points) and a high assessment of the ability to create a project (m = 4.01; SD = 0.17), which indicates formed teamwork skills and the belief that projects develop programming skills.

The Q5 question allowed us to evaluate students' knowledge of IT cloud services for project work. Prior to the experiment, CG and EG had little experience with specialized services, limited to IDE and Microsoft Teams. After the experiment, EG's knowledge expanded significantly (the average score increased from 2.36 to 3.72).

Questions Q6–Q7 revealed the positive attitude of EG students towards project-based learning as a means to gain practical experience close to real conditions. Teamwork skills in EG increased from 2.04 to 3.4 (in CG—from 2.0 to 2.14). Analyzing the results of the answers to question Q8, EG's self-assessment of the use of project and team skills in professional activities also increased (from 2.22 to 3.41).

The survey results demonstrate that the integration of PBL using professional cloud tools enhances both the technical and professional-personal competencies of IT students. The EG showed a significant increase in self-assessment of programming skills, confidence in

TABLE 1 Professional cloud services for software development.

IT direction	Cloud service	Opportunities
Collaboration in cloud office suites	Microsoft Office 365, Microsoft Teams	Collaboration and collaboration in cloud office suites provide the ability for multiple users to simultaneously access and edit documents, track changes and versioning, and integrate with other services.
Training and software development	Google Cloud Platform (GCP), Google Appl Engine	The cloud platform provides a wide range of cloud services, including computing power, data storage, databases, artificial intelligence, analytics, and more.
	Microsoft Azure	The cloud platform provides cloud services similar to AWS and GCP, such as computing power, data storage, artificial intelligence, etc. Azure also has integrations with other Microsoft products such as Office 365 and Visual Studio, making it easy to project work with multiple tools in one ecosystem.
	GitHub	Cloud platform for hosting and collaborating on projects using the Git version control system. GitHub provides options for storing and managing code, tracking changes through GitHub Issues and Pull Requests, creating issues, and discussing projects
	Google Colab	Cloud platform - a free environment for developing and executing program code in the cloud, a collaboration tool
	Heroku	A platform for deploying, scaling and managing web applications. Heroku makes it quick and easy to deploy applications using a variety of programming languages and frameworks
	MS Visual Studio, PhpStorm, Eclipse, Arduino IDE, CodeAnywhere and et.	Cloud services, which are integrated software development environments (IDEs)

TABLE 2 Questionnaire for assessing programming, project work, and teamwork skills of students.

Questions	1 – very low, 2 – low, 3 – medium, 4 – high, 5 – very high level				
	1	2	3	4	5
Q1: Evaluate your programming skills					
Q2: Do you know how to implement a joint IT project?					
Q3: Evaluate your ability to create an IT project					
Q4: Do you think working on a project in a team develops programming skills?					
Q5: Is it possible to use cloud services to organize work and collaborate in a team when developing an IT project?					
Q6: Do you think project-based training allows you to gain practical experience working on real projects?					
Q7: Evaluate your ability to work in a team when implementing an IT project					
Q8: Evaluate your ability to apply project and teamwork skills in your professional activities					

TABLE 3 Pre- and post-survey results (means, standard deviations).

Q	Control group (CG)				Experimental group (EG)			
	Means pre-survey	Means post-survey	SD (pre-survey)	SD (post-survey)	Means pre-survey	Means post-survey	SD (pre-survey)	SD (post-survey)
Q1	2.8	2.9	0.69	0.35	2.76	3.73	0.58	0.68
Q2	2.14	2.38	1.4	0.53	2.09	3.22	0.49	0.42
Q3	1.71	1.85	0.68	0.65	1.72	4.01	0.66	0.17
Q4	2.9	3.04	0.6	0.27	2.86	3.59	0.6	0.53
Q5	2.48	2.52	0.49	0.49	2.36	3.72	0.46	0.39
Q6	1.7	2.1	0.75	0.43	1.64	3.55	0.64	0.5
Q7	2.0	2.14	0.57	0.48	2.04	3.4	0.61	0.48
Q8	2.19	2.29	0.46	0.41	2.22	3.41	0.49	0.48

TABLE 4 Pre- and post-testing results.

Results	Control group (CG) (N = 21)			Experimental group (EG) (N = 22)			Comparison of results CG vs. EG			
	Average score	SD	Var	Average score	SD	Var	t-value	p-value	Cohen's d	Interpretation
Pre-test	65.8	5.2	27.04	67.0	5.7	32.49	-0.74	0.46	0.21	No differences
Post-test	71.6	3.9	15.21	82.1	3.2	10.24	-9.41	<0.0001	2.92	Very big difference

creating IT projects, and teamwork skills. Knowledge about professional cloud tools and how they can be used for collaborative development has significantly expanded. In addition, the students noted that PBL provides an opportunity to acquire practical experience that is as close as possible to the conditions of the real industry.

A quantitative analysis of the results of pre- and post-testing during the experiment to compare the academic results of students is presented in Table 4. The results of pre-testing indicate a comparable initial level of knowledge in the CG and EG, which is an important condition for ensuring the reliability of experimental results.

Before applying the t-test, the basic statistical assumptions were verified: (1) the normality of the distribution was evaluated (to test the H_0 hypothesis), the feature distributions did not have significant asymmetries or outliers; (2) the uniformity of variances was verified by comparing standard deviations using the Fisher test. For the Pre-test, the variances in CG and EG are similar ($\approx 1.2 < 2$), for the Post-test, the variances are also similar. This allowed us to conclude that the conditions for using the t-test have been met. Cohen's d effect size was applied, in addition to p-values, to determine the practical relevance of the results.

In accordance with the experimental plan, the homogeneity of the CG and EG groups was checked, and the significance of the differences in the pre- and post-test data was assessed using a t-test to compare the values of the two groups. A comparative analysis of the Pre-test data showed no statistically significant differences between the control and experimental groups ($t = -0.74$, $p = 0.46$, Cohen's d = 0.21). This confirms the homogeneity of the groups before the start of the experiment.

The results of the Post-test t-test showed statistically significant differences between the control and experimental groups and are accompanied by a very large effect size ($t = 9.41$, $p < 0.0001$, Cohen's d = 2.92). In the EG, there is a significant increase in the proportion of students who scored "excellent" (on a scale of 90–100). The grades

"unsatisfactory" (scores 0–49) and "satisfactory" (scores 50–55) disappear completely or are significantly reduced, which indicates the effectiveness of the proposed pedagogical impact.

EG students showed a high increase in knowledge in the field of software development: the average test score changed from 67.0% (SD = 5.7) to 82.3% (SD = 3.2). At the same time, KG students showed minor improvements: the average test score changed from 65.8% (SD = 5.7) to 71.6% (SD = 3.9). Thus, there is a 15.3% increase in learning outcomes in EG, and only 5.8% in KG. These results prove the effectiveness of PBL using professional cloud-based tools in teaching IT students programming.

The results of the study show that the use of cloud-based tools enhances the effectiveness of PBL in IT education compared to traditional approaches. Cloud technologies simplify project training and collaboration by providing round-the-clock access to resources and the ability to continue projects outside the classroom, including mixed and remote formats. However, their successful application requires a well-developed digital infrastructure and optimization of university resources (Rijal et al., 2024; Eljak et al., 2024; Qasem et al., 2020). Cloud technologies increase the efficiency of interaction between students and teachers, provide access to materials through LMS and contribute to the growth of academic performance. Their use in PBL enhances collaborative discussion and practical work on projects, which improves learning outcomes compared to traditional lecture methods (Grover and Nandal, 2024; Chueh and Kao, 2024).

Professional software platforms and tools play a key role in the training of IT students. Cloud services make it possible to reproduce the standards of the IT industry and increase students' willingness to work. Research shows that the use of industrial tools accelerates adaptation in practice and improves results (Hazrat et al., 2023). Therefore, the use of PBL with cloud services is advisable not only in programming, but also in other disciplines, provided that the integration is pedagogically sound and the planned learning outcomes are achievable.

5 Conclusion

PBL plays a key role in shaping the competencies of IT specialists. The study confirmed the effectiveness of PBL in teaching programming and showed the potential for integrating professional cloud-based tools, which enhances the educational effect through flexibility, collaboration, bringing tasks closer to real conditions and optimizing costs.

However, despite the evident potential of PBL and the advantages of using cloud services, the study revealed a number of limitations and challenges:

- In the process of planning training, the expediency of using PBL and the selection of adequate cloud technologies for a particular discipline should be taken into account;
- Dependence on a stable Internet connection;
- Financial constraints: significant subscription and license costs may be required to make the advanced functionality of cloud platforms and services available;
- The organization and control of project work using cloud technologies requires high digital competence from teachers, time to learn new tools, which increases the workload and requires additional training.

The results confirm the pedagogical value of PBL with cloud services, allowing students to combine theoretical knowledge with practical skills. At the same time, the issues of integrating cloud technologies into education and teacher training remain relevant, which opens up prospects for further research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethical Committee of E. A. Buketov Karaganda University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YS: Writing – review & editing, Supervision, Methodology, Conceptualization. NG: Writing – original draft, Formal analysis, Data curation. IS: Formal analysis, Data curation, Writing – review & editing. DK: Supervision, Writing – original draft, Conceptualization, Validation. SZ: Resources, Formal analysis, Writing – original draft, Supervision.

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References

Adri, M., Ganefri, S., Wahyuni, T., Zakir, S., and Jama, J. (2020). Using ADDIE instructional model to design blended project-based learning based on production approach. *Int. J. Adv. Sci. Tech.* 29, 1899–1909.

Afanasiev, I. V., Vysotskaya, N. V., Alferov, V. N., and Grigorieva, N. A. (2021). The use of cloud resources and services in distance learning of students in the context of restrictions caused by the pandemic. *Rev. Tempos Espaços Educ.* 14:e16103. doi: 10.20952/revtee.v14i33.16103

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *SAGE Open* 10, 1–15. doi: 10.1177/2158244020938702

Al-Qora'n, L. F., Jawarneh, A., and Nganji, J. T. (2023). Toward creating software architects using Mobile project-based learning model (Mobile-PBL) for teaching software architecture. *Multimodal Technol. Interact.* 7:31. doi: 10.3390/mti7030031

Alves, L. M., Ribeiro, P., and Machado, R. J. (2018). "Project-based learning: an environment to prepare IT students for an industry career" in *Computer systems and software engineering: concepts, methodologies, tools, and applications*. ed. I. Management Association (Hershey, PA, USA: IGI Global Scientific Publishing), 1931–1951.

Barbosa, M. W. (2022). Using blended project-based learning to teach project management to software engineering students. *Int. J. Mob. Blend. Learn.* 14, 1–18. doi: 10.4018/IJMBL.291978

Bogdan, R., Pop, N., and Holotescu, C. (2019). Using web 2.0 technologies for teaching technical courses. AIP Conference Proceedings.

Bryzgalova, O. N. (2021). Project-based training in the system of professional training of students: goals and problems of implementation. *Koinon* 2, 195–212 (In Russ.). doi: 10.15826/koinon.2021.02.4.048

Çakiroğlu, Ü., and Erdemir, T. (2018). Online project based learning via cloud computing: exploring roles of instructor and students. *Interact. Learn. Environ.* 27, 547–566. doi: 10.1080/10494820.2018.1489855

Ceh Varela, E., Canto-Bonilla, C., and Duni, D. (2023). Application of project-based learning to a software engineering course in a hybrid class environment. *Inf. Softw. Tech.* 158:107189. doi: 10.1016/j.infsof.2023.107189

Chen, J., Kolmos, A., and Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *Eur. J. Eng. Educ.* 46, 90–115. doi: 10.1080/03043797.2020.1718615

Chueh, H., and Kao, C. (2024). Exploring the impact of integrating problem based learning and agile in the classroom on enhancing professional competence. *Heliyon* 10, 3, 1–11. doi: 10.1016/j.heliyon.2024.e24887

Dahham, O., and Fawareh, H. (2022). E-Learning Migration Model for Cloud-based Education, in 2022 International Arab Conference on Information Technology (ACIT), (Abu Dhabi, United Arab Emirates), 1.

Dai, Z., Yang, Y., Chen, Z., Wang, L., Zhao, L., Zhu, X., et al. (2025). The role of project-based learning with activity theory in teaching effectiveness: evidence from the internet of things course. *Educ. Inf. Technol.* 30, 4717–4749. doi: 10.1007/s10639-024-12965-9

Dema, C., and Choden, U. (2024). Impact of project-based learning on computer science education. *Educ. Innov. Pract.* 7, 1–27. doi: 10.17102/eip.7.2024.08

Eljak, H., Ibrahim, A. O., Saeed, F., Hashem, I. A. T., Abdelmaboud, A., and Syed, H. J. (2024). E-learning-based cloud computing environment: a systematic review, challenges, and opportunities. *IEEE Access* 12, 7329–7355. doi: 10.1109/ACCESS.2023.3339250

Gao, Z., and Yang, H. (2023). Practice and challenges of project-based learning in physics education. *J. Educ. Educ. Res.* 5, 253–255. doi: 10.54097/jeer.v5i3.13755

Ghosheh Wahbeh, D., Najjar, E. A., Sartawi, A. F., Abuzant, M., and Daher, W. (2021). The role of project-based language learning in developing students' life skills. *Sustainability* 13:6518. doi: 10.3390/su13126518

Gosen, J., and Washbush, J. (2004). A review of scholarship on assessing experiential learning effectiveness. *Simul. Gaming* 35, 270–293. doi: 10.1177/1046878104263544

Grover, V., and Nandal, M. (2024). "Education system using cloud computing: a proposed model" in *Educational perspectives on digital Technologies in Modeling and Management*. eds. G. Prakasha, M. Lapina, D. Balakrishnan, and M. Sajid (Hershey: IGI Global Scientific Publishing), 178–194.

Guo, P., Saab, N., Post, L. S., and Admiraal, W. (2020). A review of project-based learning in higher education: student outcomes and measures. *Int. J. Educ. Res.* 102:101586. doi: 10.1016/j.ijer.2020.101586

Hazrat, M. A., Hassan, N. M. S., Chowdhury, A. A., Rasul, M. G., and Taylor, B. A. (2023). Developing a skilled workforce for future industry demand: the potential of digital twin-based teaching and learning practices in engineering education. *Sustainability* 15:16433. doi: 10.3390/su152316433

Kilpatric, W.H. (1918). The project method: the use of the purposeful act in the educative process. Available online at: https://education-uk.org/documents/kilpatrick1918/index.html (Accessed June 25, 2025).

Kldiashvili, E., Abiatari, I., and Zarnadze, M. (2025). Project-based approach as methodology to improve academic performance of medical school students within the research line teaching course: a quasi-experimental study. *Health Sci. Rep.* 8:e70562. doi: 10.1002/hsr2.70562

Kovalevskaia, N., Gilyazeva, E. N., Lobazova, O. F., Duborkina, I. A., and Sokolova, A. P. (2021). Impact of digital services of hybrid cloud-based learning environment on efficiency of education. *Rev. Tempos Espaços Educ.* 14:e15297. doi: 10.20952/revtee.v14i33.15297

Lescano, N., and Yamao, E. (2023). "Project based learning approach for cloud application development course using agile methodologies" in *2022 International Symposium on Accreditation of Engineering and Computing Education (ICACIT)*, (Cusco, Peru: IEEE Publisher), 1–4.

Marini, A., Safitri, D., Niladini, A., Zahari, M., Dewiyani, L., and Muawana, U. (2025). Developing a website integrated with project-based learning: evidence of stimulating creativity among elementary school students in Indonesia. *Soc. Sci. Humanit. Open* 11:101402. doi: 10.1016/j.ssaho.2025.101402

Marnewick, C. (2023). Student experiences of project-based learning in agile project management education. *Proj. Lead. Soc.* 4, 1–12. doi: 10.1016/j.plas.2023.100096

Naik, V., and Girase, S. (2021). Project based learning methodology: an effective way of learning software engineering through database design and web technology project. *J. Eng. Educ. Transform.* 34, 375–379. doi: 10.16920/jeet/2021/v34i0/157182

O'Connor, S., Power, J., Blom, N., and Tanner, D. (2024). Engineering students' perceptions of problem and project-based learning (PBL) in an online learning environment. *Aust. J. Eng. Educ.* 29, 88–101. doi: 10.1080/22054952.2024.2357404

Ohiri, E. (2023). The role of cloud computing in the it sector—2023. Available online at: https://www.cudocompute.com/blog/the-role-of-cloud-computing-in-the-it-sector (Accessed July 23, 2025).

Omelchenko, T. V., and Omelchenko, P. N. (2021). Experience of using 1C cloud services and technologies to organize the learning process in the IT directions of training. *Inform. Educ.* 2, 62–68. (In Russ.). doi: 10.32517/0234-0453-2021-36-2-62-68

Perifanou, M., and Economides, A. A. (2025). Collaborative uses of GenAI tools in project-based learning. *Educ. Sci.* 15:354. doi: 10.3390/educsci15030354

Qasem, Y. A. M., Abdullah, R., Yaha, Y., and Atana, R. (2020). Continuance use of cloud computing in higher education institutions: a conceptual model. *Appl. Sci.* 10:6628. doi: 10.3390/app10196628

Rawat, P. (2024). Top cloud computing skills for career growth in 2024. Available online at: https://www.icertglobal.com/top-cloud-computing-skills-you-need-to-know-in-2024-blog/detail (Accessed July 23, 2025).

Rehman, N., Huang, X., Mahmood, A., AlGerafi, M., and Javed, S. (2024). Project-based learning as a catalyst for 21st-century skills and student engagement in the math classroom. *Heliyon* 10:e39988. doi: 10.1016/j.heliyon.2024.e39988

Rijal, S., Zou, G., Jie, L., and Jixiong, C. (2024). The impact of using a cloud-based learning management system on access and quality of education. *J. Emerg. Tech. Educ.* 2, 163–176. doi: 10.70177/jete.v2i2.1062

Rochev, K., and Semyashkina, A. (2023). Joint project-based training of IT students based on the use of version control tools and task separation in the project. *RUDN J. Inform. Educ.* 20, 52–62. (In Russ.). doi: 10.22363/2312-8631-2023-20-1-52-62

Saad, A. (2022). The effectiveness of project based learning with computational thinking techniques in a software engineering project course. *J. Contemp. Issues Thought* 12, 65–79. doi: 10.37134/jcit.vol12.1.6.2022

Sindre, G., Giannakos, M., Krogstie, B. R., Munkvold, R., and Aalberg, T. (2018). Project-based learning in IT education: definitions and qualities. *Uniped* 41, 147–163. doi: 10.18261/ISSN.1893-8981-2018-02-06

Spirina, Y. A., Gorbunova, N. A., and Samoilova, I. A. (2024). Using MOOCs to organise problem-based learning in the professional training of IT students. *Educ. Sci. J.* 10, 166–189. doi: 10.17853/1994-5639-2024-10-166-189

Srikan, P., Pimdee, P., Leekitchwatana, P., and Narabin, A. (2021). A problem-based learning (PBL) and teaching model using a cloud-based constructivist learning

environment to enhance Thai undergraduate creative thinking and digital media skills. *Int. J. Interact. Mob. Technol.* 15:68. doi: 10.3991/ijim.v15i22.24963

Suswanto, H., Hamdan, A., Mariana, R. R., Dardiri, A., Wibawa, A. P., Nafalski, A., et al. (2017). The effectiveness of project-based learning and STAD learning on improving web programming competency. *World Trans. Eng. Techn. Educ.* 15, 368–373.

Tang, S., Ratana-Olarn, T., and Petsangsri, S. (2023). Enhancing project-based learning (PBL) in cloud education models for word software courses. *Pak. J. Life Soc. Sci.* 21, 14–27. doi: 10.57239/PJLSS-2023-21.1.0024

Teixeira, R.L.P., Silva, P.C.D., Shitsuka, R., de Araújo Brito, M.L., and Kaizer, B.M. (2020). Project-based learning in engineering education in close collaboration with industry in 2020 IEEE Global Engineering Education Conference, (Porto, Portugal: EDUCON), 1945–1953.

Thomas, J.W. (2000). A review of research on project-based. https://tecfa.unige.ch/proj/eteach-net/Thomas_researchreview_PBL.pdf (Accessed June 15, 2025).

Wang, Y. (2023). The role of computer supported project-based learning in students' computational thinking and engagement in robotics courses. *Think. Skills Creat.* 48:101269. doi: 10.1016/j.tsc.2023.101269

Yu, P. L., Fang, S. C., and Wang, Y. L. (2016). Improving IT professionals' job skills development: the use of management styles and individual cultural value orientation. *Asia Pacific Manage. Rev.* 21, 63–73. doi: 10.1016/j.apmrv.2015.07.002

Zhang, L., and Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. *Front. Psychol.* 14:1202728. doi: 10.3389/fpsyg.2023.1202728