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Research Article

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# A Practice-Oriented Approach to Teaching Python Programming for University Students

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**Abstract:** The objective of this study was to examine the effectiveness of a practice-oriented approach in teaching Python programming to students in Kazakhstan. The study participants comprised students from a control group (CG) and an experimental group (EG), with 89 students in each group. The mean age of the participants was 20 years. The sample included 93 male students and 85 female students. The CG followed a traditional teaching methodology, whereas the EG was instructed using an innovative approach. The applied research methods included theoretical and practical tests, surveys, and interviews with instructors. The results demonstrated that the average score in the theoretical test increased from 67.8 to 82.1 ($p$ = 0.0001) for the EG, whereas the CG's score improved from 65.2 to 71.3 ($p$ = 0.0002). During practical testing, the average score for the EG rose from 70.7 to 81.9 ($p$ = 0.0003), while the CG's score increased from 70.1 to 77.3 ($p$ = 0.0001). The findings suggest that the practice-oriented approach contributes to the enhancement of theoretical knowledge, practical skills, and student engagement in Python programming education. The practical significance of the results lies in determining the effectiveness of innovative teaching methods in fostering both theoretical and practical competencies.

**Keywords:** practice-based learning approach; programming curriculum; programming skills development; project-based learning; student education

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## 1 Introduction

In the context of global digitalization and the expanding application of information technologies worldwide, leading countries are actively developing national programs for training IT specialists. For instance, in the United States, project-based learning is integrated into STEM education, facilitating students' mastery of complex technical disciplines and enhancing their critical thinking skills (Williamson 2023). China actively employs innovative methods in programming education, including the integration of video lectures with elements of structural and project-based scaffolding, which has led to a significant improvement in students' computational thinking skills (Wan et al. 2024).

One of the key national programs aimed at increasing the competitiveness of Kazakhstan's economy is the Digital Kazakhstan program (Baimukhamedov et al. 2022). Its objectives include the expansion of digital infrastructure, the implementation of innovative technologies across various economic sectors, and the development of a workforce equipped with modern IT skills (Zheksembayeva 2021). In this context, the training of qualified programming specialists capable of meeting the growing demands of the labor market is of particular importance (Patrushev and Bespaly 2021).

Among the most widely used technologies in the field of information technology is the Python programming language (Dhruv et al. 2021). Python is extensively applied in data analysis, process automation, web development, artificial intelligence, and machine learning (Ashurova 2022). Its popularity is attributed not only to its ease of learning but also to its versatility, making it an optimal choice for student education. Python consistently ranks highly in programming language ratings, such as those conducted by TIOBE and Stack Overflow, further underscoring its significance in the global IT industry (Ashurova 2022; Dhruv et al. 2021). Its application across diverse fields, including finance, healthcare, communications, and public administration, highlights the necessity of incorporating it into educational curricula. Furthermore, Python enables the integration of automation tools, big data analysis, and machine learning algorithm development, which is particularly relevant in the context of increasing digitalization (Van Hattem 2022). However, the professional training system in programming faces several challenges. Foundational computer science education at universities presents significant difficulties. Currently, the training of future programming instructors is either superficial or entirely excluded from computer science curricula (Prokopiev et al. 2020). Such an approach may demotivate students who fail to perceive the real value of the subject they are studying. Additionally, the rapid advancement of technology necessitates the swift adaptation of educational programs, requiring the integration of innovative approaches into the learning process. Computer science courses typically cover only the basics of programming without fostering the practical application of acquired skills (Prokopiev et al. 2020). Furthermore, there is a shortage of qualified educators capable of effectively combining practical skills with the theoretical knowledge essential for the implementation of real-world projects (Markula and Aksela 2022; Sun et al. 2023).

On the one hand, the volume of knowledge that university graduates are expected to acquire is rapidly increasing. On the other hand, the abilities and motivation levels of the student population vary significantly, and this differentiation continues to grow (Dolinsky 2023). Scholars and educators seek solutions to these challenges in the following areas: revising the knowledge requirements for university admission in accordance with the realities of timely acquisition; utilizing new information technologies to simplify and enhance the learning process; and developing new teaching methodologies that reflect current realities (Dolinsky 2023).

A practice-based approach to programming education presents an effective solution to these issues. This approach incorporates real-world problems based on authentic scenarios into the learning process. For example, students engage in projects that simulate industry-related tasks, such as developing web applications, conducting data analysis, or automating routine processes (Ashurova 2022; Van Hattem 2022). These skills enable students to develop critical thinking, teamwork abilities, and problem-solving competencies. Moreover, students not only gain an understanding of fundamental programming concepts but also acquire practical experience essential for building a successful career. Additionally, a practice-oriented approach allows students to create a portfolio of real-world projects, thereby significantly improving their employability prospects (Dilafruz 2023).

The present study was motivated by the need to analyze and justify the use of a practice-oriented approach to Python programming education in universities in Kazakhstan. Given the increasing demand for domestic IT specialists, it is essential to identify strategies that will enhance graduates' competitiveness in the global labor market (Myrzaev et al. 2024). The findings of this study contribute to the development of effective strategies for implementing practical approaches, which can be utilized to update academic curricula. Ultimately, these advancements will support the growth of Kazakhstan's IT sector and address the challenge of workforce training in alignment with contemporary requirements. Furthermore, this study explores potential mechanisms for collaboration between universities and IT companies to jointly implement educational projects and internships.

Thus, addressing the topic of practice-oriented approaches to Python programming education not only meets labor market demands but also contributes to the implementation of the Digital Kazakhstan national program (Baimukhamedov et al. 2022; Patrushev and Bespaly 2021; Zheksembayeva 2021). Given the dynamic evolution of technologies and the changing educational landscape, research in this area has become increasingly important from both scientific and practical perspectives. This highlights the necessity of exploring various instructional methods to enhance the quality of professional training while considering the needs of the modern digital economy. By employing a practice-oriented approach, students acquire not only foundational knowledge but also the skills required for active participation in digital transformation.

### 1.1 Literature Review

Contemporary approaches to programming education in Kazakhstani universities are actively explored in the context of digitalization and the integration of IT into academic curricula (Baimukhamedov et al. 2022; Zheksembayeva 2021). International studies emphasize the significance of project-based learning and practice-oriented methods in enhancing the quality of IT specialist training (Dilafruz 2023). Swedish researchers point out that theoretical and practical components of academic programs are mutually reinforcing, and frequent transitions between them foster student engagement and improve knowledge retention (Eckerdal et al. 2024). Chinese scholars have demonstrated that the implementation of innovative learning tools substantially enhances practical skills, fosters innovative thinking, and improves Python programming competencies in the fields of artificial intelligence and big data analytics (Liu and Guo 2024).

Although computer literacy, ICT, educational technologies, and digital citizenship are integral elements of informatics, they differ from computer science education in that they focus primarily on the use of software rather than understanding its underlying mechanisms or developing new technologies (Connolly et al. 2022). In this regard, eight key variables have been identified – perceived enjoyment, friendliness, ease of learning, social influence, creative and programming self-efficacy, and attitudes toward collaboration – all of which positively affect students' behavioral intentions toward learning programming (Milutinović 2024). Structured programming curricula have been introduced in the United Kingdom (2014), Germany (2016), and in South Korea, China, and Taiwan since 2016 (Belmar 2022). Thus, the topic under investigation remains relevant and warrants further in-depth examination.

Russian scholars concluded that practice-oriented learning and the development of interdisciplinary skills are key contemporary trends in preparing future specialists (Khaimina et al. 2023). Other researchers argue that programming education is becoming increasingly popular and that offering introductory MOOCs (Massive Open Online Courses) in programming could serve as a means to make this education accessible to a broader audience (Lepp et al. 2018). Turkish scholars highlight key themes in teachers' responses, including the improvement of educational quality, adaptation to technological advancements, and the integration of technology into the learning process (Eğin et al. 2025).

The primary challenge in this field lies in the gap between theory and practice, outdated curricula, and limited instructional methods (Lin and Fang 2023). A notable research gap persists in the comprehensive assessment of practical programming skills, particularly regarding code quality and algorithmic thinking (Lajis et al. 2018). The implementation of project-based learning requires substantial resources, posing difficulties for certain universities (Othman et al. 2023; Padzil et al. 2021; Sun et al. 2023). Although practice-oriented teaching methods have demonstrated their effectiveness, further research is needed to elucidate the mechanisms underlying their success and to develop universal pedagogical guidelines. Project-based learning proves effective in small-group settings, yet its efficacy may diminish with larger student cohorts.

The novelty of this study lies in its comprehensive approach to the implementation of practical Python programming exercises within the context of Kazakhstani higher education. It proposes the integration of project-based methods and modern educational technologies to enhance professional training in the era of digital transformation. A review of the literature reveals the absence of unified standards for the integration of project-based learning and a lack of empirical evidence regarding its effectiveness, underscoring the need for further investigation. Consequently, this research addresses both academic and practical demands, contributing to the improvement of specialist training quality under contemporary educational conditions.

### 1.2 Problem Statement

The motivation for this study lies in the development and justification of a practice-oriented approach to Python programming education for university students in Kazakhstan. This approach aims to enhance students' professional skills to meet the demands of the digital economy and align the academic curriculum with the needs of the IT industry. The objective of this article is to develop and demonstrate a practical approach to Python programming education for Kazakhstani students while integrating the curriculum with industry requirements.

The research hypothesis posits that a practice-oriented approach to Python programming education, based on project-based activities and active collaboration with industry, contributes significantly to enhancing students' professional competence. This includes the development of analytical thinking, teamwork skills, and the ability to solve applied problems. The effectiveness of this approach is particularly evident in the context of the digital transformation of education in Kazakhstan.

Research Objectives:

- To develop and implement a model of practice-oriented Python programming education within the academic curriculum.
- To assess the effectiveness of the proposed educational model by analyzing students' academic performance and satisfaction with the learning process.
- To evaluate students' comprehension of the curriculum and their interest in innovative teaching approaches.
- To collect feedback from instructors involved in teaching students in the experimental group.

## 2 Research Methods

### 2.1 Study Design

In this study, the research design adopts a mixed-methods approach, incorporating both quantitative and qualitative methodologies to comprehensively assess the effectiveness of the proposed teaching method. The quantitative methods involve evaluating students' theoretical and practical knowledge at the beginning and end of the learning process, allowing for an assessment of their readiness for different stages of the educational process and, consequently, identifying any changes that have occurred. This enables an objective measurement of students' academic performance based on clear numerical data.

The qualitative research methods complement the quantitative data by providing a deeper understanding of how students perceive the program and its impact on their motivation and interest. For instance, surveys and interviews facilitate the identification of subjective aspects, such as instructors' perspectives on the use of project-based learning methods, students' attitudes toward new teaching approaches, and their overall satisfaction with the learning process. The integration of these two methods creates a comprehensive framework that captures both measurable outcomes (knowledge acquisition) and the personal experiences and observations of study participants.

## 2.2 Sampling

The study was conducted over four months at a university in Kazakhstan. The sample for this research comprised second- and third-year students from the technical faculties of the following universities in Kazakhstan: Ozbeksali Zhanibekov South Kazakhstan Pedagogical University, Khoja Akhmet Yassawi International Kazakh-Turkish University in Turkestan, and Korkyt Ata Kyzylorda University. The total sample size consisted of 178 participants, including 75 students from Ozbeksali Zhanibekov South Kazakhstan Pedagogical University, 60 students from Khoja Akhmet Yassawi International Kazakh-Turkish University, and 43 students from Korkyt Ata Kyzylorda University. The sample included 93 male and 85 female students, aged between 19 and 21 years.

The inclusion criteria for the study were as follows: second-and third-year students from technical faculties residing in Kazakhstan who had actively participated in full-time educational programs over the last two semesters. This cohort was selected as it represents an optimal level of knowledge and experience necessary for engaging with both traditional and innovative learning tasks. Such a selection facilitates a clear comparison between conventional and innovative teaching methodologies. Furthermore, these students were able to actively participate in solving applied problems and assess the effectiveness of the project-based learning approach, particularly in the context of application development and process automation.

The exclusion criteria included students not enrolled in technical specializations, senior-year students with a more advanced level of knowledge, and students with significant absenteeism. Additionally, 10 instructors who conducted the training participated in the study and were surveyed upon its completion.

## 2.3 Procedure

During the study, students were divided into groups. The control group (CG) consisted of 89 students who were taught Python programming using traditional methods, including lectures and standard laboratory sessions. This group followed a conventional curriculum without the introduction of project-based tasks. The experimental group (EG) also comprised 89 students, who participated in a Python programming curriculum focused on application development, data analysis, and task automation, incorporating project-oriented assignments. This approach enabled an assessment of the effectiveness of new educational technologies.

The instructional methods used for the experimental group emphasized active and innovative approaches aimed at developing practical skills in real-world scenarios while deepening students' theoretical knowledge. In contrast to traditional methods, which primarily consist of standard lectures and laboratory sessions, the experimental group's learning process also included team-based work, participation in hackathons, and engagement in programming competitions. The instructional approach used for the experimental group is described in detail in Table 1.

The objective of this experimental group-based learning method is to develop practical skills, creative thinking, and teamwork abilities, thereby enhancing student engagement in the learning process and preparing them for real-world professional challenges.

## 2.4 Research Tools

As part of the study, the following tests were developed to assess students' theoretical knowledge and practical skills before and after the learning process. The theoretical and practical tests (Appendix 1), designed specifically for the training program, aimed to provide a comprehensive evaluation of students' theoretical understanding and practical competencies in programming, data analysis, and software development. The assessment of theoretical and practical knowledge consisted of 10 tasks, each scored on a 10-point scale, with a maximum possible score of 100 for the test.

Subsequently, a survey was conducted among the experimental group (EG) students to gather data on their perceptions of the course and their interest in innovative teaching methods (Appendix 2). The survey was administered using Google Forms, facilitating efficient data collection and processing. The questionnaire included statements assessing motivation, interest, and awareness of the teaching methods, rated on a 5-point Likert scale (ranging from

**Table 1:** Student learning in the experimental group.

| Training in the experimental group (EG) | |
|---|---|
| 1. Solving Problems Based on Real-World Cases | Data Collection: Students work with company-provided data, conducting market research, analyzing customer behavior, and compiling statistical information.<br>Data Processing: Students utilize data analysis tools such as Python, Excel, and specialized software for big data processing. They work with datasets, enabling them to apply theoretical knowledge in practice.<br>Business Problem-Solving: Students develop solutions to help companies enhance processes, optimize production operations, improve resource efficiency, or refine marketing strategies.<br>Results Presentation: Students learn not only to solve problems but also to present their findings to client companies, thereby developing communication skills and the ability to defend their solutions with reasoned arguments. |
| 2. Team-Based Project Work | Role Distribution: Within each team, students assume different roles (e.g., developer, analyst, project manager), allowing each participant to leverage their strengths while developing collaborative skills.<br>Coordination of Actions: Students teach one another effective teamwork strategies by addressing emerging challenges, developing solutions, and analyzing interim results.<br>Project Documentation: Throughout the process, students create project documentation, plans, and reports, fostering project management skills and enhancing their ability to maintain technical documentation.<br>Project Implementation: Teams engage in long-term projects, such as mobile application development, software prototyping, and business process automation, providing students with practical experience highly valued in the labor market. |
| 3. Participation in Hackathons and Competitions | Idea Implementation Within a Limited Timeframe: During hackathons, students are presented with a problem that must be solved within a short period (e.g., 20–30 min). This fosters their ability to make quick decisions, enhances creativity, and develops resilience under pressure.<br>Competition with Other Teams: Participation in hackathons and programming competitions allows students to compare their solutions with those of other teams, fostering a drive for improvement and self-development.<br>Receiving Expert Feedback: Through these events, students gain valuable insights and constructive criticism from industry professionals, enabling them to refine their projects and enhance their professional skills.<br>Networking Opportunities: Hackathons and competitions provide students with the chance to engage with company representatives, potential employers, and peers from other universities, which can be beneficial for their career development. |

Source: developed by the author.

"strongly disagree" to "strongly agree"). The survey was conducted by instructors at the end of the training sessions, after students had completed all assignments and projects. The average time to complete the survey was approximately 15–20 min. To ensure fairness and transparency, student responses were anonymized.

Additionally, interviews were conducted with instructors teaching students in the experimental group to collect their insights and observations (Appendix 3). The interviews took place at the end of the study period, following the experiment. They were conducted in person, allowing for direct interaction and detailed discussions on individual issues. Each interview lasted approximately 30–40 min. The interview questions focused on instructors' perceptions of the new teaching methods, challenges faced, and suggestions for improving the curriculum. The interviews were conducted in an informal setting, enabling instructors to express their thoughts and observations freely. Their responses were recorded and analyzed to identify key themes that could be used to enhance future courses.

The reliability of the research instruments (theoretical and practical tests) was evaluated using Cronbach's alpha reliability coefficient. The coefficient yielded values of 0.73 for theoretical assessments and 0.78 for practical assessments, indicating high reliability of the instruments. Additionally, Cronbach's alpha was used to assess the reliability of the survey and interview instruments, resulting in values of 0.79 and 0.81, respectively, further confirming the reliability of the assessment tools.

## 2.5 Data Analysis and Processing

The test results were analyzed using statistical methods to determine differences between the control group (CG) and the experimental group (EG). For each theoretical and practical test question, the mean group score (ranging from 0 to 100) was calculated, reflecting overall trends in students' responses to specific statements. The Student's *t*-test was employed to evaluate differences in knowledge test results between the control and experimental groups. This test was selected as it compares the mean values of two independent samples, making it particularly suitable for assessing the impact of project-based learning methods on student learning outcomes.

In analyzing the survey results, descriptive statistical methods were applied to calculate the percentage of student responses to each survey question. This approach allows for a clear and accessible presentation of data, facilitating the identification of trends and patterns among respondents. Each survey question was analyzed using a Likert scale, where response options were scored as follows: 1 – "Strongly Disagree," 2 – "Disagree," 3 – "Neutral," 4 – "Somewhat Agree," and 5 – "Strongly Agree." These percentages illustrate the degree to which students agree or disagree with various statements, enabling an assessment of their perceptions of the project-based learning approach in the curriculum.

The interview data were analyzed using thematic analysis to identify key themes and recurring ideas among different instructors. Responses were recorded and categorized into themes such as "positive observations," "challenges," and "recommendations for improvement." This method provides a deeper understanding of instructors' perceptions of the new teaching methods and facilitates the identification of areas for further curriculum enhancement.

### 2.6 Ethical Issues

All participants in the study, including both students and instructors, provided informed consent to participate in the experiment. They were informed about the purpose of the study, data collection methods, and potential implications of their participation. Participation was voluntary, and individuals had the right to withdraw from the study at any time without any consequences. All collected data, including survey responses and interview transcripts, were anonymized. Participants' identities were not disclosed, and responses were processed solely for research purposes. Furthermore, all data were securely stored and used exclusively for academic research, ensuring confidentiality and compliance with ethical research standards. To minimize potential power imbalances between teachers and students, especially in cases where the teacher is a researcher, it was emphasized that participation did not affect grades or academic progress. Data collection was carried out after the completion of the learning module, and the processing of the results was carried out independently of the teaching process.

### 2.7 Research Limitations

The student sample was limited to technical programs from three universities in Kazakhstan, which may restrict the generalizability of the findings to students in other academic programs or countries. This limits the applicability of the study results to a broader population. Additionally, the study did not account for the influence of external factors, such as students' personal circumstances or extrinsic motivation, which may have affected their participation and performance. These factors could have introduced bias into the data, particularly in students' perceptions of the learning process. Despite employing a mixed-methods approach, this study lacked sufficient longitudinal measures to accurately assess long-term changes in students' academic and professional skills. The effects of the project-based learning approach may take time to manifest, potentially limiting conclusions regarding its long-term effectiveness. Furthermore, the qualitative data obtained through interviews and surveys may reflect participants' subjective opinions and preferences, which could affect the objectivity of the results – especially if participants already had a preference for a practice-based approach.

## 3 Results

### 3.1 Testing Results

Table 2 presents a comparative analysis of the theoretical and practical knowledge assessment results for students in the control group (CG) and the experimental group (EG) before and after training, allowing for an evaluation of the effect of traditional and innovative teaching methods. This study utilized theoretical and practical tests, with each test scored on a scale from 1 to 10, yielding a total possible score of 100. The mean score and standard deviation (SD) for each test are provided in Table 2. Additionally, the T-values for independent samples and P-values are reported to assess the statistical significance of differences between the groups.

In the theoretical test, the control group (CG) demonstrated an increase in the mean score from 65.2 to 71.3, while the standard deviation remained nearly unchanged (5.4 and 5.5, respectively). This indicates a moderate improvement in knowledge, primarily attributed to the acquisition of theoretical concepts through traditional teaching methods. However, the $t$-value of 4.21 and $p$-value of 0.0002 suggest that this improvement is statistically significant.

**Table 2:** Student test results.

| Group | Pre-test | | Post-test | | *t*-value | *p*-value |
|---|---|---|---|---|---|---|
| | Mean score | Standard deviation | Mean score | Standard deviation | | |
| **Theoretical testing** | | | | | | |
| CG | 65.2 | 5.4 | 71.3 | 5.5 | 4.21 | 0.0002 |
| EG | 67.8 | 6.2 | 82.1 | 5.7 | 4.47 | 0.0001 |
| **Practical testing** | | | | | | |
| CG | 70.1 | 7.8 | 77.3 | 6.7 | 3.27 | 0.0001 |
| EG | 70.7 | 7.1 | 81.9 | 5.8 | 3.87 | 0.0003 |

Source: developed by the author.

In the experimental group (EG), the mean score increased from 67.8 to 82.1, while the standard deviation decreased from 6.2 to 5.7. This reflects a substantial increase in theoretical knowledge, accompanied by greater consistency in students' performance within the group. The statistical significance of these changes was confirmed with a *t*-value of 4.47 and a *p*-value of 0.0001.

Similar results were observed in practical tasks. In the control group, the mean score increased from 70.1 to 77.3, and the standard deviation decreased from 7.8 to 6.7, indicating a notable improvement in practical skills. These changes were statistically significant, as evidenced by a *t*-value of 3.27 and a *p*-value of 0.0001.

In the experimental group, the mean score increased from 70.7 to 81.9, while the standard deviation decreased from 7.1 to 5.8, suggesting both a significant enhancement in students' skills and more stable performance across the group. The statistical significance of these improvements was confirmed with a *t*-value of 3.87 and a *p*-value of 0.0003.

The increase in mean scores in the control group (CG) was the result of a natural learning process, in which students assimilated material through traditional teaching methods. However, the improvement in knowledge and skills remained modest due to the limitations of the traditional approach, which is often less effective in enhancing student motivation and engagement.

In contrast, the significant improvement observed in the experimental group (EG) was attributed to the use of innovative teaching methods, such as active student participation, project-based learning, and the integration of modern technologies. These factors contributed to a deeper understanding of theoretical concepts and the development of practical skills while also reducing performance variability among participants. Thus, the study results demonstrate the advantages of innovative teaching approaches, which facilitate greater learning progress and a more uniform distribution of knowledge among students.

**Table 3:** Summary of student results and additional analysis.

| Group | Testing | Increase in mean score (%) | Coefficient of variation (%, Before/After) |
|---|---|---|---|
| CG | Theoretical | 9.4 % | 8.3/7.7 |
| | Practical | 10.3 % | 11.1/8.7 |
| EG | Theoretical | 21.0 % | 9.1/6.9 |
| | Practical | 15.8 % | 10.0/7.1 |

Source: developed by the author.

Table 3 presents the performance analysis of students in both the control and experimental groups, along with an additional statistical analysis of post-training changes. This analysis focuses on two aspects: the increase in mean scores and changes in the coefficient of variation, which allows for an assessment of both the overall learning progress and the degree of knowledge uniformity within each group. In the control group, the mean score on the theoretical test increased by 9.4 %, indicating a moderate improvement in academic performance. The coefficient of variation decreased from 8.3 % to 7.7 %, reflecting a slight improvement in the homogeneity of students' knowledge. In the practical exam, the mean score increased by 10.3 %, while the coefficient of variation decreased from 11.1 % to 8.7 %, suggesting a greater improvement in the uniformity of knowledge and skills compared to the theoretical exam.

## 3.2 The Results of the Survey

Figure 1 illustrates the distribution of responses from students in the experimental group (EG) regarding their perception of project-based learning in Python programming. The

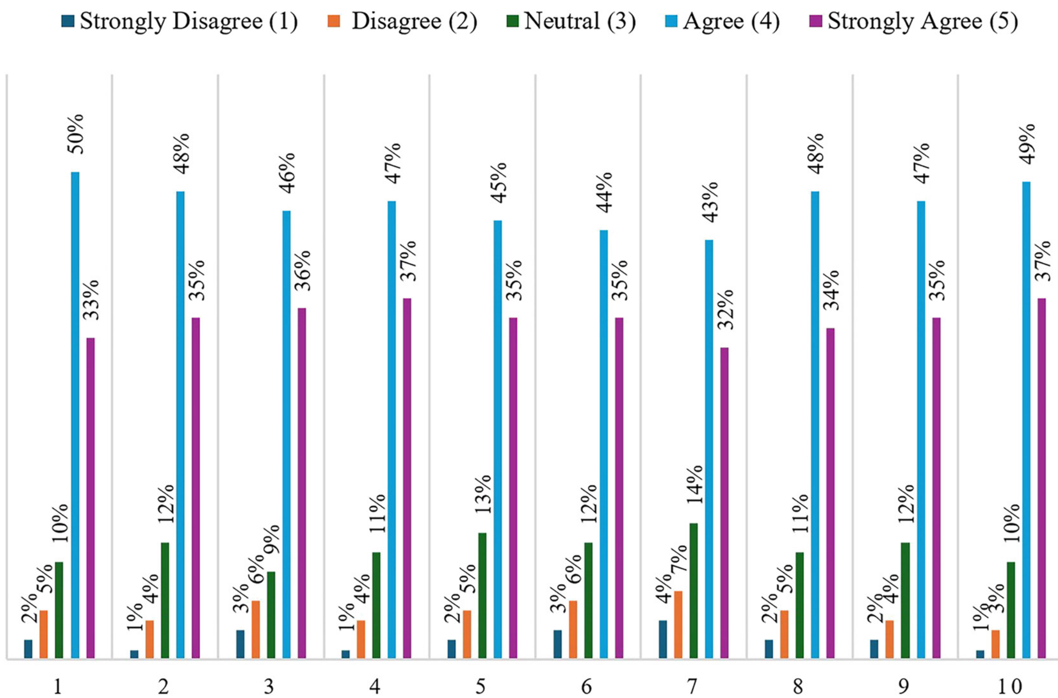


**Figure 1:** Survey results. Source: Developed by the author.

responses were recorded using a Likert scale, ranging from “strongly disagree” to “strongly agree”. The first question reveals that the majority of students perceive the project-based approach as effective in deepening their understanding of Python programming. 83 % of students responded with “agree” or “strongly agree,” while only 7 % disagreed, confirming the positive perception of this approach and its educational effectiveness.

In response to the second question, 83 % of students indicated that project-based work enables them to acquire practical skills applicable to real-life scenarios. This highlights the importance of practical tasks in professional development. The third question shows that learning Python through teamwork was perceived as more engaging, with 82 % of students agreeing with this statement. Only 9 % responded with “neutral”, indicating an overall positive perception of collaborative learning.

The fourth question indicated that the majority of students (84 %) were interested in solving tasks related to real-world examples. This suggests that such assignments effectively stimulate interest in learning Python.

For the fifth question, 80 % of students responded positively, indicating that project-based learning helps prepare them for their future professional careers. However, 13 % of students were uncertain in their assessment, which may indicate the need for further analysis.

The sixth question revealed that 79 % of respondents found working on a project challenging yet engaging. This suggests that the level of difficulty was appropriately set to foster interest and engagement.

The seventh question demonstrated that 75 % of students preferred learning through real-world projects over traditional lectures and practical exercises. However, 14 % were undecided, which may reflect individual learning preferences that should be considered in curriculum development.

The eighth question showed that 82 % of students reported that project-based learning increased their motivation to study Python programming, confirming the motivational role of this approach in the educational process.

For the ninth question, 82 % of students stated that the process of application development and data analysis was both useful and interesting, indicating the successful integration of practical elements into the curriculum.

Regarding the tenth question, 86 % of students stated that they would recommend project-based learning to others, suggesting a high overall level of satisfaction with this approach.

Thus, as shown in Figure 1, the majority of students expressed a positive attitude toward project-based learning in Python programming. This approach supports the development of practical skills and professional preparation while also enhancing student engagement and motivation through hands-on tasks and teamwork.

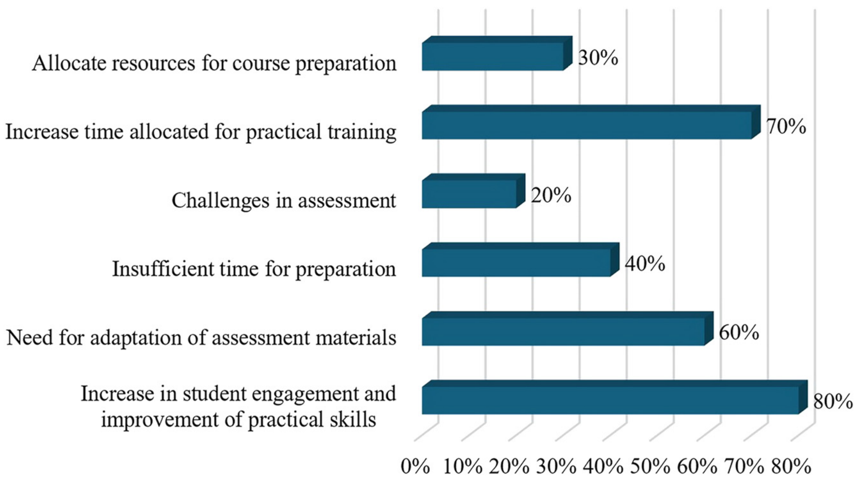


**Figure 2:** Interview results. Source: Developed by the author.

### 3.3 Results of Interviews with Teachers

During the interviews, instructors shared their observations and various aspects related to the implementation of project-based learning (Figure 2). Many instructors reported that students demonstrated increased interest in the learning process, actively engaged in project activities, and developed self-directed learning skills. Additionally, 80 % of instructors noted an increase in student engagement and an improvement in practical skills. However, instructors also encountered challenges, such as the need to allocate more time for preparing materials and assessing projects, as well as the requirement for professional development to effectively implement the new teaching approach.

Furthermore, 60 % of instructors indicated that assessment materials need to be adapted to align with this teaching method. Additionally, 40 % noted insufficient preparation time, while 20 % reported challenges related to assessment and the need for additional time for preparation. Overall, educators believe that project-based learning enhances students' critical thinking and creative abilities; however, its implementation requires significant effort and resources. 70 % of instructors suggested increasing the time allocated for practical work, while 30 % proposed allocating resources for course preparation. Although the positive feedback from instructors confirms the effectiveness of project-based learning, the identified challenges suggest that successful implementation of this approach requires additional training and resources.

## 4 Discussion

The study confirmed the effectiveness of practice-oriented instruction in Python programming: students in the experimental group significantly outperformed those in the control group on both theoretical and practical tasks. The project-based approach facilitates a deeper understanding of theoretical concepts and improves knowledge application, while also enhancing student motivation. Similar outcomes have been reported in other studies, including research conducted in Malaysia, where practical learning significantly improved students' problem-solving skills and the ability to develop real-world software solutions (Ibrahim et al. 2020).

Theoretical assessments demonstrated knowledge gains in both groups, but the improvement was more pronounced in the experimental group: the average score increased from 67.8 to 82.1, compared to 65.2 to 71.3 in the control group. American studies likewise confirm that students engaged in project-based learning achieve higher scores on standardized assessments and exhibit greater levels of self-reflection (Krajcik et al. 2023). Chinese researchers have also found that innovative learning tools enhance practical skills and foster innovative thinking (Liu and Guo 2024). This effect can be attributed to the nature of project-based learning, which engages students through real-world tasks, thereby deepening both theoretical and practical understanding.

A comparison of performance on practical tasks revealed a similar pattern: while the control group showed moderate improvement (from 70.1 to 77.3), the experimental group demonstrated a substantial increase (from 70.7 to 81.9). These results further confirm the efficacy of practice-oriented approaches that integrate theoretical knowledge with active application. Research from China has shown that project-structured instructional videos improve computational thinking, particularly in the areas of algorithmic reasoning and collaborative work (Wan et al. 2024). Kazakhstani scholars have likewise confirmed that project-based learning enhances content mastery and practical skills acquisition (Liu et al. 2023), with the experimental group achieving statistically significant results compared to the control group ($p$ = 4.187). A Ukrainian study found that a structured programming curriculum effectively develops problem-solving competencies, as reflected in the considerable improvement in programming proficiency among students in the experimental group (Bazurin et al. 2022). Another Chinese study affirmed that project-based instruction enhances academic performance, affective attitudes, and cognitive skills (Zhang and Ma 2023). These findings underscore that the project-based approach stimulates autonomous problem-solving and promotes the development of programming and critical thinking abilities.

The findings of this study confirm the high potential of a practice-oriented approach in enhancing the quality of Python programming education in Kazakhstani universities. Students who participated in project-based learning demonstrated higher levels of knowledge and skills, indicating the effectiveness of this method in teaching complex technical disciplines. Similar results were reported in Indonesia, where the average score of the experimental group reached 82.2 compared to 72.5 in the control group (Sembiring et al. 2023). Cuban researchers have also noted improvements in students' problem-solving and project management skills through report writing, which contributes to the development of core competencies and enhances student competitiveness (Rojas et al. 2024).

Another Kazakhstani study (Karstina et al. 2024) examined the characteristics of practice-oriented educational technologies in teaching technical and natural science disciplines. The results indicated that specialists increasingly prioritize the development of personal, social, and technical competencies. This underscores the need for integrating practical approaches into Kazakhstan's educational system. Given the rapid pace of technological advancement and shifts in the labor market, it is essential to prepare students not only for theoretical understanding but also for the practical application of knowledge. The implementation of innovative methods, particularly project-based learning, represents a key step toward improving the quality of higher education.

At the same time, it is important to consider Kazakhstan's local specificities: disparities in students' digital literacy levels, limited access to modern technologies in certain regions, and the structural transformation of the national education system. These factors may influence learning outcomes and highlight the need to adapt practice-oriented approaches to the national context. Thus, the present study contributes to the existing body of knowledge by drawing attention to the realities and challenges of Kazakhstani higher education.

## 5 Conclusions

The findings confirm that the project-based approach to Python programming education significantly enhances students' theoretical knowledge and practical skills. In the experimental group (EG), the mean score on the theoretical knowledge assessment increased from 67.8 to 82.1, while the mean score on the practical knowledge assessment improved from 70.7 to 81.9. Additionally, the variability of results decreased, indicating a more uniform proficiency level in Python programming. These changes were statistically significant, as evidenced by the $t$-value and $p$-value ($p < 0.001$). The control group (CG) also demonstrated improvement, with the mean score increasing from 65.2 to 71.3 ($p = 0.0002$) on the theoretical test and from 70.1 to 77.3 ($p = 0.0001$) on the practical test. A student survey revealed that 83 % of respondents considered the project-based approach highly effective for deepening their understanding of programming, while 80 % stated that it was beneficial for their professional preparation. The teacher survey results further emphasized the positive impact of this approach, with 80 % of instructors reporting increased student engagement and 60 % highlighting the need for modifications in assessment materials and methods.

The practical and scientific significance of this study lies in its demonstration of the advantages of innovative teaching methods, which contribute to deeper subject mastery, the development of practical skills, and increased student motivation. These findings can be utilized to optimize educational programs in Kazakhstani universities, enhance the quality of education, and better prepare students for professional careers. Additionally, the results may inform the implementation of project-based learning in educational institutions and support the development of market-oriented curricula. Furthermore, they can be applied in the creation of educational platforms that integrate modern IT solutions with project-based tasks. The recommendations of this study include the integration of a project-based approach into university programs in Kazakhstan, ensuring that students gain hands-on experience relevant to industry needs. Another key recommendation is the development of an interactive platform that facilitates collaboration between universities and IT companies, aligning academic programs with current labor market demands. To enhance the quality of education, it is also necessary to adapt curricula to modern educational standards, ensuring that students receive training that meets industry requirements. For the successful implementation of project-based learning, additional measures are required, such as faculty training, which would help instructors effectively apply innovative teaching methodologies. Providing up-to-date resources is also crucial to ensure that students have access to the necessary tools and technologies. Furthermore, the development of effective assessment methods for project-based learning is essential to objectively evaluate student progress and outcomes.

Further research directions may include an examination of the effectiveness of project-based learning across various educational contexts. It is essential to conduct studies to adapt this approach to different stages of student training, including undergraduate and graduate education. Additionally, it is necessary to investigate the impact of this approach on the development of critical thinking, creativity, and teamwork skills across different professional fields. One promising research area is the development of new methods for integrating information technologies and platforms to automate learning and assessment processes. In the long term, this includes the creation of scalable learning models that can be adapted to various educational institutions, taking into account the specific nature of disciplines and labor market needs. Furthermore, it is important to assess the economic efficiency of implementing new teaching methods and their impact on teacher and student satisfaction.

Researchers should also focus on developing mechanisms for university-IT industry collaboration, updating curricula to align with industry demands, and ensuring that students have access to relevant tools and technologies. This may involve the establishment of partnerships for internships, joint projects, and case-based learning, providing students with practical experience in real-world professional settings.

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# Appendix 1

**Theoretical Tests:**

(1) What is a variable in a programming language?
(2) Explain the difference between code compilation and interpretation.
(3) What data types exist in Python?
(4) What is an array, and how is it used?
(5) Explain the working principle of a hash table.
(6) What is database normalization?
(7) Explain the difference between INNER JOIN and LEFT JOIN in SQL.
(8) Explain the difference between supervised and unsupervised learning in machine learning.
(9) What is model overfitting, and how can it be mitigated?
(10) What is DevOps, and how does it influence the development process?

**Practical Tests:**

(1) Write a function that calculates the factorial of a number.
(2) Write a program that checks whether a given string is a palindrome.
(3) Develop a Python script that reads a CSV file and generates statistical summaries of the data.
(4) Implement a K-means clustering algorithm for data classification.
(5) Write an SQL query to retrieve all orders placed by a specific user.
(6) Implement a procedure for updating product information in a database.
(7) Write a script that automatically fetches data from a website.
(8) Develop a server monitoring system that sends notifications in case of failures.
(9) Create a CI/CD pipeline for automatic application deployment.
(10) Organize a code review process to improve code quality in a project.

# Appendix 2

**Student Survey Questions (Evaluation of the Educational Process in Python Programming Training):**

(1) The project-based learning approach contributes to a deeper understanding of Python programming.

(2) Working on projects has helped me acquire practical programming skills.
(3) Teamwork has made the process of learning Python more engaging and productive.
(4) Solving real-world case-based problems sparked my interest and stimulated my learning.
(5) The project-based approach helped me understand how Python programming skills can be applied in professional settings.
(6) Project-related assignments were challenging yet engaging and informative.
(7) I prefer learning through real-world projects rather than traditional lectures and laboratory exercises.
(8) Completing project assignments increased my motivation to study Python programming.
(9) The process of developing software and analyzing data in Python was useful and interesting.
(10) Overall, I recommend using the project-based learning approach for Python programming education for other students.

**Likert Scale Response Options:**
(1) – Strongly Disagree
(2) – Disagree
(3) – Neutral
(4) – Agree
(5) – Strongly Agree

# Appendix 3

**Interview Questions for Instructors (Evaluation of Teaching Practices):**
(1) How do you assess the effectiveness of the project-based learning approach in student education?
(2) What challenges did you encounter in organizing student project work?
(3) How do you evaluate student engagement in the project development process?
(4) In your opinion, what improvements could be made to enhance the effectiveness of project-based learning?
(5) What observations or recommendations do you have for improving teaching methodologies in the future?

# References


Ashurova, M.M. (2022). Programming language python methodology for creating and using didactic materials for students. *Galaxy Int. Interdiscip. Res. J.* 10: 63–67.

Baimukhamedov, M.F., Baimukhamedova, G.S., and Aimurzinov, M.S. (2022). Economic development within the framework of the state program “Digital Kazakhstan”. *Actual Sci. Res. Mod. World* 10: 200–204.

Bazurin, V.M., Chashechnikova, O.S., Karpenko, Y.M., Pursky, O.I., and Palchuk, P.M. (2022). Interdisciplinary problems of mathematical content as a means of teaching programming to secondary school pupils. *J. Phys.: Conf. Ser.* 2288: 012010.

Belmar, H. (2022). Review on the teaching of programming and computational thinking in the world. *Front. Comput. Sci.* 4: 997222.

Connolly, C., Byrne, J.R., and Oldham, E. (2022). The trajectory of computer science education policy in Ireland: a document analysis narrative. *Eur. J. Educ.* 57: 512–529.

Dhruv, A.J., Patel, R., and Doshi, N. (2021). Python: the most advanced programming language for computer science applications. In: *Proceedings of the international conference on culture heritage, education, sustainable tourism, and innovation technologies (CESIT 2020)*. SCITEPRESS, pp. 292–299.

Dilafruz, A. (2023). The Practice-oriented approach to learning in Europe. In: Mendoza, C.N. (Ed.). *10th-International conference on research in humanities, applied sciences and education*. Conferencea, pp. 79–80, Available at: https://conferencea.org/index.php/conferences/article/view/1939.

Dolinsky, M. (2023). Trends in the development of basic computer education at universities. *Buletin Ilmiah Sarjana Teknik Elektro* 5: 584–591.

Eckerdal, A., Berglund, A., and Thuné, M. (2024). Learning programming practice and programming theory in the computer laboratory. *Eur. J. Eng. Educ.* 49: 330–347.

Eğin, F., Onan, A., and Yildiz Durak, H. (2025). Let’s talk about EdTech! A topic modelling analysis of AI tools and pre-service teachers’ perspectives. *Eur. J. Educ.* 60: e12913.

Ibrahim, M.F., Huddin, A.B., Hashim, F.H., Abdullah, M., Rahni, A.A.A., Mustaza, S.M., Hussain, A., and Zaman, M.H.M. (2020). Strengthening programming skills among engineering students through experiential learning based robotics project. *Int. J. Eval. Res. Educ.* 9: 939–946.

Karstina, S., Zhetpisbajeva, B., Tussupbekova, A., and Makhanov, K. (2024). Application of practice-oriented education technologies in training students in engineering and science specialties. *Sci. Anal. J. “High. Sch. Kazakhstan”* 46: 56–67.

Khaimina, L.E., Demenkova, E.A., Zelenina, L.I., Demenkov, M.E., Khaimin, E.S., and Zashikhina, I.M. (2023). Project-based learning: formation of students’ digital competencies. In: *2023 3rd International conference on technology enhanced learning in higher education (TELE)*. IEEE, pp. 178–180.

Krajcik, J., Schneider, B., Miller, E.A., Chen, I.C., Bradford, L., Baker, Q., Bartz, K., Miller, C., Li, T., Codere, S., et al. (2023). Assessing the effect of project-based learning on science learning in elementary schools. *Am. Educ. Res. J.* 60: 70–102.

Lajis, A., Baharudin, S.A., Ab Kadir, D., Ralim, N.M., Nasir, H.M., and Aziz, N.A. (2018). A review of techniques in automatic programming assessment for practical skill test. *J. Telecommun. Electron. Comput. Eng.* 10: 109–113.

Lepp, M., Palts, T., Luik, P., Papli, K., Suviste, R., Säde, M., Hollo, K., Vaherpuu, V., and Tõnisson, E. (2018). Troubleshooters for tasks of introductory programming MOOCs. *Int. Rev. Res. Open Distr. Learn.* 19: 56–75.

Lin, Y. and Fang, L. (2023). Exploring innovations in teaching reform for Python programming under engineering education accreditation. In: *Proceedings of the 2nd international seminar on artificial intelligence, networking and information technology (ANIT 2023)*. SCITEPRESS, pp. 355–361.

Liu, Q. and Guo, J. (2024). Course reform and practice of "Python programming" for artificial intelligence and big data applications. *J. Comput. Technol. Electron. Res.* 1: 1–5.

Liu, Z., Alimbekov, A., Glushkov, S., and Ramazanova, L. (2023). Modern tendency to practice-oriented learning. *Mendel* 29: 155–161.

Markula, A. and Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Discipl. Interdiscip. Sci. Educ. Res.* 4: 2.

Milutinović, V. (2024). Unlocking the code: exploring predictors of future interest in learning computer programming among primary school boys and girls. *Int. J. Hum. Comput. Interact.* 41: 3149–3165.

Myrzaev, R., Seitmuratov, A., Kanibaykyzy, K., Ibraeva, A., Kuralbaeva, A.A., and Nuskabay, P.N. (2024). Professional focus of mathematical training of bachelors in it directions. *Sci. J. "Bull. NAS RK"* 408: 234–248.

Othman, J., Mahlan, S.B., Kadar, R., Shamsuddin, M., and Wahab, N.A. (2023). Factors affecting engineering students in learning the programming subject at UiTM Pulau Pinang: a study on educators' ability. *Int. J. Acad. Res. Prog. Educ. Dev.* 12: 944–953.

Padzil, M.R., Abd Karim, A., and Husnin, H. (2021). Employing DDR to design and develop a flipped classroom and project based learning module to applying design thinking in design and technology. *Int. J. Adv. Comput. Sci. Appl.* 12: 791–798.

Patrushev, A.A. and Bespaly, S.V. (2021). State program "Digital Kazakhstan": implementation and development trends. In: Haliuta, J. (Ed.). *Modern problems, trends and prospects of socio-economic development*. Surgut State University, pp. 271–274, Available at https://elibrary.ru/item.asp?id=47216149.

Prokopiev, M.S., Vlasova, E.Z., Tretiakova, T.N., Sorochinsky, M.A., and Soloveva, R.A. (2020). Development of a programming course for students of a teacher training higher education institution using the programming language Python. *Propositos y Representaciones* 8: 33.

Rojas, L.R.M., Martínez, M.G., and Burguera, G.J.M. (2024). Development of competencies from project-oriented learning. *ITEGAM-JETIA* 10: 30–37.

Sembiring, J., Mubai, A., Dakhi, O., and Edi, F. (2023). Project-oriented self-directed learning as a learning model to improve learning outcomes. In: Ambiyar, A., Verawardina, U., and Dakhi, O. (Eds.). *9th International conference on technical and vocational education and training (ICTVET 2022)*. Atlantis Press, pp. 116–121.

Sun, J., Ma, H., Zeng, Y., Han, D., and Jin, Y. (2023). Promoting the AI teaching competency of K-12 computer science teachers: a TPACK-based professional development approach. *Educ. Inf. Technol.* 28: 1509–1533.

Van Hattem, R. (2022). *Mastering Python: write powerful and efficient code using the full range of Python's capabilities*. Packt Publishing Ltd, Birmingham.

Wan, H., Zhang, X., Yang, X., and Li, S. (2024). Which approach is effective: comparing problematization-oriented and structuring-oriented scaffolding in instructional videos for programming education. *Educ. Inf. Technol.* 29: 17807–17823.

Williamson, E. (2023). The effectiveness of project-based learning in developing critical thinking skills among high school students. *Eur. J. Educ.* 1: 1–11.

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.

Zheksembayeva, A. (2021). Comparative analysis and coverage of the state program "Digital Kazakhstan" of the state program for the development of the tourism industry of the Republic of Kazakhstan 2019-2025. *Student J.* 18: 6–9.