Original Research Article

A study on project-based teaching in computer science programs in the context of industry-education integration

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Abstract: Against the backdrop of industry-education integration, enterprises are placing higher demands on the cultivation of applied talent. However, current teaching practices face challenges such as students' lack of practical experience and technical skills in corporate projects, outdated teaching content and development tools, and imprecise assessment methods. This study proposes a reform of practical courses in computer science based on small-scale corporate projects. First, the course content was restructured around project development technologies. Second, an implementation framework is established to organize teaching activities according to corporate project development workflows. This approach fosters a deep integration of industry and education, helping to enhance students' practical skills.
Keywords: corporate projects; content restructuring; project-driven; competency assessment

1. Introduction

Currently, educational content lags behind technological advancements in the industry, making it difficult to promptly integrate engineering technologies into the classroom. This has led to a disconnect between the structure of talent development and industry requirements. Breaking through this bottleneck has become a central challenge in the reform of higher engineering education in China. The integration of industry and education is viewed as a strategic measure to effectively link the talent pipeline to the industrial chain. Based on this, this study uses typical engineering projects as a vehicle to design and propose a project-based teaching approach that follows the engineering development process.

2. Review of related research

2.1. Integration of industry and education

The integration of industry and education is a strategic approach to promoting the organic integration of the education, talent, industrial, and innovation chains [1]. With the advancement of national policies, many universities have launched talent development models based on industry-education integration. In December 2021, the Beijing Economic-Technological Development Area, in collaboration with Tsinghua University, Peking University, the Institute of Microelectronics of the Chinese Academy of Sciences, and leading enterprises in the industry, jointly established the Beijing Integrated Circuit Industry-Education Integration Base. As of February 2025, 34 national-level municipal industry-education consortia have been established, further deepening the integration of industry and education. Additionally, leveraging the regional advantages of Silicon Valley—A global hub for high-tech innovation—Stanford University has emphasized application-oriented approaches and interdisciplinary complementarity, successfully developing a joint curriculum between its School of Business and School of Engineering [2].

2.2. Project-based learning

Project-based learning (PBL) is a student-centered teaching model organized around real-world problems/tasks. In the context of industry-education integration, PBL refers to an approach that uses real-world industrial projects as a vehicle to optimize curriculum content and organize teaching activities in accordance with corporate project development processes, with the aim of comprehensively enhancing students' engineering practical skills. PBL is currently widely applied in various disciplines, including computer science[3], e-commerce[4], and English[5]. Practical teaching experience indicates that this method helps improve student performance and enables them to acquire industry-relevant skills.

2.3. Current issues in computer talent development

Compared to industry hiring needs, computer science curricula at applied universities generally suffer from the following issues: 1) the technologies and development tools covered in the curriculum lag behind mainstream industry standards; 2) students' enterprise-level coding skills and hands-on practical abilities are relatively weak; and 3) students lack a clear understanding of project development processes. Against the backdrop of industry-education integration, and by combining corporate project development experience with the characteristics of computer practice courses, we have restructured the curriculum around projects and designed an implementation pathway for project-based computer practice course instruction.

3. Project-based instructional design

To cultivate computer professionals who meet industry needs, this study implements educational reforms in two areas: Curriculum content and the organization of teaching activities. The curriculum content has been restructured into four components: Theoretical content, laboratory exercises, development tools, and competency-based learning. The organization of teaching activities is divided into six phases aligned with the enterprise project development process.

3.1. Curriculum content restructuring

(1) Restructuring of Theoretical Content, To ensure technical alignment with corporate project development, we will first integrate enterprise-level project codes and industry programming standards into the curriculum; second, we will introduce mainstream enterprise development frameworks; and finally, we will embed key machine learning technologies into project-based instruction to achieve a deep integration of traditional software engineering with intelligent computing methods.

(2) Restructuring of Experimental Content: A three-tiered, progressive project-based learning system was established based on a difficulty gradient. The first tier consists of individual challenge-based experiments: A question bank of challenges is created based on typical pitfalls in enterprise development, with exercises covering environment setup and troubleshooting. The second tier consists of individual comprehensive simulation experiments: individual tasks are designed within simulated enterprise-level scenarios to complete the basic functionality of simple web projects. The third tier consists of real-world project work: Real corporate projects are introduced, and teams are organized to engage in end-to-end practices such as requirements alignment, task allocation, version control, code reviews, and continuous integration and deployment.

(3) Project Development Tools: We incorporated enterprise-level development tools into our curriculum and training system, covering commonly used tools such as IntelliJ IDEA, Maven, Git, Tomcat, MySQL, Navicat, Anaconda, VS Code, MobaXterm, Wireshark, and JMeter. The goal is to help students build a core toolchain aligned with software engineering practices while developing their hands-on and problem-solving abilities.

In summary, this study restructured the curriculum in three key areas, resulting in a new curriculum framework guided by industry needs and supported by real-world engineering experience.

3.2. Implementation pathways

To foster a deep integration of industry and education and enhance students' understanding of and practical skills in enterprise project development processes, this course uses the GitHub platform to simulate an enterprise-level collaborative development environment. Instructional activities are organized according to the actual project lifecycle, with the content of Section 3.1 appropriately distributed across the six phases of the project: Preliminary research, project preparation, requirements analysis and design, development, testing, and final review.

(1) Project Preliminary Research Phase: The curriculum for this phase covers enterprise-level development frameworks, core concepts and algorithms in machine learning, and standard programming techniques and engineering standards. In terms of teaching methods, this phase moves away from traditional one-way knowledge transfer and primarily employs a case-driven, discussion-based approach to teaching. By selecting typical industry application scenarios, students are guided to independently map and connect knowledge from abstract principles to specific engineering contexts through analysis, debate, and

synthesis.

(2) Project Preparation Phase: This phase focuses on setting up an enterprise-level development environment. Students are guided through the installation and configuration of essential tools, such as the JDK, Maven, Git, an IDE, and a database, and are instructed to successfully import and run the seed project provided by the instructor. This ensures that all students proceed with subsequent engineering projects from a common technical foundation.

(3) Requirements Analysis and Design Phase (Group Presentation): Under the instructor's guidance, students conduct a systematic requirements analysis based on their chosen topics. Through user stories, use case diagrams, and feature lists, they clarified the system's core business logic and functional boundaries. They then proceeded to complete the system's high-level and detailed designs. This includes drawing system architecture diagrams, designing database ER models, defining interfaces, and dividing modules. This phase emphasizes the standardization and feasibility of design documents, guiding students to develop systematic engineering thinking and master methods for translating requirements into designs.

(4) Development and Implementation Phase: This phase constitutes the core engineering practice component. Students will adopt a front-end/back-end separation architecture as the basic paradigm and adhere to coding standards to implement core functionalities, including user management, video processing, data storage, machine learning algorithm integration, and recommendation engines, on a module-by-module basis. The use of Git for version control is mandatory throughout the development process, and team collaboration and code reviews are conducted on the Gitee platform to simulate enterprise-level development workflows.

(5) Testing and Validation Phase: Students write and execute unit tests and interface test cases for the implemented features and conduct cross-functional and basic performance tests. Through systematic testing activities, they verify functional compliance, interface stability, and the system's ability to handle edge cases while tracking and fixing any defects discovered. This phase focuses on developing students' quality awareness and their debugging skills.

(6) Final Evaluation Phase: Each project team completes the system deployment and prepares for the demonstration. During the defense session, the teams presented their project outcomes, discussed technical challenges, and shared insights on team collaboration. Concurrently, peer evaluations among teams and a final review by faculty members are conducted, involving a comprehensive multidimensional assessment based on process documentation, code quality, system functionality, and team performance. This phase facilitates the systematic organization of knowledge, consolidation of engineering experience, and development of a mindset focused on iterative improvement.

4. Conclusion

Against the backdrop of industry-education integration, this study aims to effectively enhance students' comprehensive project implementation capabilities and familiarize them with corporate project management and development processes. Using small-scale corporate projects as a vehicle, this paper restructures course content and designs instructional activities in accordance with corporate project development workflows. This approach effectively addresses issues such as students' lack of practical experience, outdated teaching content and tools, and imprecise assessment methods. Moving forward, we will further strengthen long-term collaboration with enterprises and continuously update teaching resources and platforms to enable the course to serve local industrial development and talent cultivation needs on a larger scale and at a higher level.

Fundings

This study was supported by the Jiangsu Higher Education "Qinglan Project"; General Projects of Philosophy and Social Sciences Research in Jiangsu Higher Education Institutions (2022SJYB0672, 2023JSYB0635, 2024SJYB0457); General Research Project on Higher Education Teaching Reform in Jiangsu Province (Project No.: 2025JGYB322); University-Level Key Project on Teaching Reform Research at Nanjing University of Communications (Project No.: JG20250601).

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