

Research on the Project-Based Teaching Model for Engineering Majors in Colleges and Universities

Hongli Zhang*

Qingdao Institute of Technology, Qingdao 266300, Shandong Province, China

*Corresponding author: Hongli Zhang, zhanghongli@qit.edu.cn

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Abstract: Based on the study of the Mechanical Design and Automation major and its relevance to teaching reform in higher education engineering programs, a project-based teaching model was introduced. This approach integrates teaching design, scheme argumentation, and the implementation of teaching activities with the project serving as the central framework. Course knowledge points are derived from the project topics, forming the foundation for a structured knowledge framework. The course content is modularized in alignment with the project design, enabling students to engage with professional courses on a module-by-module basis, guided by the project. Each course utilizes the project topic as a practical case, facilitating project-led teaching. A teaching system tailored to the research project is proposed, establishing a professional course structure closely linked to the project objectives.

Keywords: Teaching model; Project-based teaching; Engineering majors; Teaching system

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1. Introduction

With the rapid development of science and technology and the continuous upgrading of the industrial structure, society has put forward higher requirements for the quality and ability of engineering majors in colleges and universities. The traditional teaching mode mainly based on theoretical lectures has been difficult to meet the educational needs of cultivating innovative and practical engineering talents. In this context, the project-based teaching model emerged as a novel approach and shows unique advantages in the teaching of engineering majors in colleges and universities. This teaching model emphasizes taking the project as the core, closely integrating knowledge learning with practical operations, allowing students to master professional knowledge and skills in the process of completing the project, and cultivating engineering practical skills, innovative ability, and teamwork spirit. In-depth research on the project-based teaching model in engineering majors in colleges and universities is of great significance for improving the quality of engineering talent cultivation and promoting the reform of engineering education.

In recent years, in the field of educational model research, project-based teaching research has received extensive attention. In 2021, the Process Equipment and Control Engineering major at East China University

of Science and Technology proposed a “one-core, two-wings, two-wheel-driven” practical teaching model. This model takes double-creation (innovation and entrepreneurship) as the main body. Through the overall planning of the Academic Affairs Office and the in-depth development of each college, a high-quality science and technology innovation platform integrating “teaching, scientific research, and innovation practice” is created. At the same time, a two-wheel-driven curriculum system of “theoretical teaching” and “double-creation practice” with cross-spiral promotion is designed to realize the organic combination of “learning and doing” and improve students’ comprehensive quality and engineering practice level ^[1]. In 2024, the experience and effectiveness of the “scenario-project-based” teaching reform at Chongqing Jiaotong University involves leveraging “small” teaching reforms to solve the “big” problem of talent cultivation. While the “scenario-project-based” teaching breaks the boundaries of disciplines, courses, and resources, it strengthens the integrity, systematicity, and gradation design among disciplines, and promotes the transformation of teaching from the imparting of basic knowledge to the development of core literacy.

In teaching practice, according to the needs of different development stages and the differences among disciplines, the project-based teaching model should be continuously innovated and deepened to build efficient classroom teaching.

2. Analysis of the project-based teaching model

The project-based teaching model is a teaching method that takes actual projects as the carrier and organically integrates the teaching content of the course with project practice. In this model, teachers organize teaching activities around one or more specific projects. Students acquire knowledge and skills and cultivate the ability to solve practical problems by participating in the analysis, design, implementation, and evaluation of the project. Projects can be actual engineering tasks from enterprises, teachers’ scientific research projects, or simulated projects designed according to teaching goals ^[2].

The project-based teaching has changed the previous pure classroom theoretical teaching model. It extends to the application of theoretical knowledge and can better understand and consolidate the knowledge points of the course. The implementation of project-based teaching not only reconstructs the teaching content of the course, it breaks the boundaries of textbooks and courses, builds a knowledge system around specific engineering projects, and is a remodeling and integration of teaching content. Moreover, it also changes the mode of teaching and learning. After receiving the project learning tasks, students study the corresponding knowledge points with problems. Every explanation of the knowledge point is carried out around the task, with clear learning purposes and strong initiative.

The project-based teaching is conducive to improving students’ initiative and participation in learning, changing passive acceptance to active exploration. Project-based teaching emphasizes the practicality and application of teaching, allowing students to effectively combine theoretical knowledge with practical applications in the daily learning process. This teaching and training method can better meet the needs of social enterprises for professional talents.

3. Design of project-based teaching mode for engineering majors in colleges and universities

3.1. Scheme of professional course teaching system

Taking the teaching model of engineering major courses in colleges and universities as the research object,

according to the actual work processes in enterprises, the professional courses are divided into three levels: design-oriented professional courses, production-manufacturing-oriented professional courses, and test-verification-oriented professional courses. Taking the actual engineering design projects as the main line, teaching design, design scheme demonstration, and teaching organization and implementation are carried out, and systematic application analysis of teaching methods is performed. This model builds course knowledge points centered on project tasks, reconstructs the course teaching system, innovates the teaching mode, stimulates students' learning of professional courses in the form of project topic research, and focuses on cultivating students' knowledge application ability and the ability to solve actual engineering problems.

3.2. Implementation methods

The model research is based on the mechanical design and automation major in engineering. Teachers determine the overall goals of the project according to the course syllabus and professional training objectives, combined with the actual needs of enterprises or cutting-edge issues in the discipline.

The project is decomposed into several specific sub-tasks according to functional modules or work processes. Reasonable time nodes are arranged for each sub-task, and a project-module-based learning plan is formulated. Project-based teaching runs through all levels of professional course teaching and differentiated project-based teaching schemes are adopted at different course levels. The project-based teaching model introduces actual project topics before the study of professional courses, and at the same time combs and summarizes the knowledge points of each professional course used in each project topic, so that each student can clearly know the course knowledge points that the project topic will apply when learning each professional course. In the early stage of project implementation, teachers systematically explain the relevant theoretical basic knowledge according to the knowledge field involved in the project. During the explanation process, attention is paid to the connection between the theory and the project. Through case analysis, introduction of actual problems, and other methods, students are helped to understand the application scenarios of knowledge. Teachers guide students to conduct preliminary analysis and thinking of the project, put forward some enlightening questions, and help students clarify the entry point and solution ideas of the project, encouraging students to independently explore the knowledge and technology related to the project and cultivating students' innovative thinking.

3.3. Case analysis of the teaching model

The teaching model research has conducted a demonstration study by taking the "Automatic Loading and Unloading Function Transformation Project of CNC Lathe" as the supporting case of project-based teaching. The research content of the transformation project mainly includes three aspects: the automatic feeding system, the automatic loading and unloading system, and the control system. For example, the design of the automatic feeding device involves the design of mechanisms such as the planar four-bar mechanism, the cam mechanism, and the gear mechanism in the "Mechanical Principles" course that can achieve step feeding, and the design of the belt drive device and the power device such as the motor in the "Mechanical Design" course; the design of the automatic loading and unloading device involves the design of the rack and pinion mechanism, the kinematics and dynamics design of the mechanism, the design of the connecting rod mechanism in the "Mechanical Principles" and "Mechanical Design" courses, and the knowledge points such as the cylinder design and application in the "Hydraulic and Pneumatic Transmission" course; the matching design of the control system involves the application of servo motors, the motion control programming of

PLC, the drawing of electrical circuit diagrams in the “Electrical Control and PLC” course, the application of sensors and the machine tool circuit in the “Machine Tool Electrical Control” course, and the numerical control processing programming in the “Numerical Control Programming and Processing” course. The teaching of each course is based on these project-related knowledge points for the teaching design of each course, and finally a set of project-based professional course teaching system design plans is formed based on the mechanical design and automation major ^[3].

Similarly, when organizing the teaching content of the “Mechanical Design” course, the teacher takes the “Reducer Design” as the task and teaches in accordance with the idea of project design. Each teaching content completes certain tasks in the project, allowing students to learn the corresponding knowledge points as the project progresses. In the classroom, the teacher organizes the class through project inspiration, student interaction, knowledge reserve, and task completion. While completing the learning task of the “Mechanical Design” course knowledge, the task of the “Mechanical Design Course Design” is also completed. The integration of theory with practical application enhances the learning experience by making the purpose more focused, enriching the classroom environment, and increasing student engagement. Simultaneously, aligning with the development of the social industry, the introduction of reducer design in the context of new energy vehicle electric drive axles provides students with real-world application scenarios. This approach broadens their knowledge base, improves design capabilities and practical skills, and fosters the development of engineering design concepts and innovative thinking through hands-on experience in real-world projects ^[4].

4. Innovative effects of project-based teaching model

4.1. Innovation of teaching method

The project-based teaching model adopts a hybrid teaching method combining online and offline in the actual teaching process. There are rich teaching resources for online teaching on the Internet. We can fully utilize the high-quality online resources provided by various platforms, such as texts, pictures, videos, etc., to conveniently enrich teaching content and improve teaching quality. During the teaching process, corresponding videos can be played directly by linking to the network through the smart classroom; self-built courses are used to assist teaching, and learning tasks, homework tests, achievement displays, and sharing are set in advance. The construction of online courses has greatly enriched the teaching content of the courses, providing students with a more flexible and personalized learning method. Students can use their spare time to independently choose the learning progress and depth according to their own learning rhythm and comprehension.

4.2. Innovation in curriculum modular teaching design

The project-based teaching model decomposes the knowledge points according to the project design tasks, builds the framework of the curriculum knowledge structure, divides the curriculum knowledge into modules based on the project design, and thus conducts the curriculum teaching design, allowing students to carry out professional course learning by project and module. The modular teaching design of the curriculum is conducive to connecting all knowledge points and focuses on the practicality and systematic application of knowledge.

4.3. Innovation in the school-enterprise cooperation teaching system

In order to enhance students’ learning interest, enrich classroom teaching content, and ensure high-quality

teaching, project-based teaching has effectively promoted cooperation between schools and enterprises. Both sides jointly develop projects, produce videos, etc., providing sufficient and high-quality resources for teaching activities. This closely connects the teaching content of the school with the industry demands and enables students to more intuitively apply the learned knowledge in actual working scenarios. The project-based teaching has greatly improved the teaching quality and effect, creating extremely favorable conditions for cultivating high-quality talents that meet the needs of society and enterprises.

5. Conclusion

The project-based teaching model connects the knowledge points of the courses centered on the projects, reconstructs the teaching system of the courses, promotes the optimization of the engineering professional course system, and effectively promotes the integration and expansion of teaching resources. The joint development of schools and enterprises has become an important way to expand resources. Enterprises provide schools with real project cases, advanced equipment, and technical support. Schools, on the other hand, align educational tasks with demand goals according to the needs of enterprises and cultivate tailor-made talents for enterprises. At the same time, resources such as laboratories and practical bases on campus are more fully utilized in project-based teaching, and it prompts schools to develop more project-related teaching materials^[5,6].

The project-based teaching model has significantly improved students' mastery of engineering professional knowledge, effectively stimulated students' innovative thinking and practical ability, greatly enhanced students' learning interest and enthusiasm, and cultivated students' ability to apply knowledge and solve practical problems. Thus, it is conducive to comprehensively improving students' comprehensive quality and enhancing their employment competitiveness.

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References

- [1] Ma X, 2021, Construction of the "One Core, Two Wings, and Two-Wheel-Driven" Practical Teaching Model Oriented to "New Engineering"—Taking the Process Equipment and Control Engineering Major in East China University of Science and Technology as an Example. *Mechanics in Engineering*, 43(02): 273–277.
- [2] Xu H, Zhang D, 2024, Exploration on the Project-Driven Flipped Classroom Teaching Mode Aimed at Cultivating Learning Ability. *Teaching in Forestry Region*, 2024(06): 60–63.
- [3] Zhang H, Hu L, Zhao F, 2021, Discussion on the Project-Driven Teaching Method Based on "Design of Automatic Loading and Unloading Mechanism for Machine Tools." *The Journal of New Industrialization*, 11(09): 224–225.
- [4] Wang W, 2023, Research on the Application of Project-Driven Teaching Method in Mechanical Design Teaching.

Knowledge Window (Teacher Edition), 2023(11): 123–125.

- [5] Ren S, 2024, Practice and Reflection of Project-driven Teaching Mode in Professional Skills Training Courses. Shanxi Youth, 2024(03): 102–104.
- [6] Hou G, Wang S, 2023, Engineering Training Teaching Reform Based on Project-Driven under the Background of Mass Entrepreneurship and Innovation. China Educational Technology & Equipment, 2023(21): 169–172.

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