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Difficulties and Countermeasures of Engineering Education Curriculum Reform Based on Project-Driven

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ABSTRACT
Engineering education in our country needs transformation; the traditional classroom teaching mode has made it difficult to meet the needs of industrial development for applied talents. Many enterprises have reported that although college graduates have a theoretical basis, they can not solve practical engineering problems well. The project-driven teaching model introduces students to practical engineering cases, which can effectively link learning needs and work in the classroom. Therefore, this paper focuses on the specific implementation difficulties and improvement methods in the reform of engineering education in order to provide a reference for colleges and universities to optimize teaching modes and cultivate high-quality engineering and technical talents.

KEYWORDS
Project-driven; Engineering education; Curriculum reform

1 Introduction

The main task of engineering education is to cultivate applied talents who can meet the industry's challenges. The speed of modern technological development far exceeds the update cycle of traditional teaching content, and companies' requirements for new employees have shifted from “mastering knowledge” to “solving problems." However, the existing teaching mode relies too much on textbooks and lacks an effective channel to transform knowledge into engineering practice ability. Although project-driven teaching emphasizes"Learning by doing" and reshapes the learning process by simulating real engineering scenarios, it also exposes specific contradictions, such as teachers' transformation difficulties and loose curriculum systems in the pilot process. Therefore, this paper will deeply analyze project-driven education's practical difficulties and breakthrough paths to explore a more resilient implementation plan for engineering education reform.

2 Application Background of Project-Driven Teaching Mode in Engineering Education

2.1 An Overview of Project-Driven Teaching Mode

Project-driven teaching is like a practical class where you learn by doing, treating real engineering problems as learning tasks. For example, when learning to build a house, traditional classrooms first require memorizing material strength formulas and drawing standard blueprints. However, after studying for several months, you still do not know how to build a small house. Project-based teaching lets you lead teams in designing simple kennels. From measuring and selecting materials to calculating support forces to building the framework, you have to solve real problems with your brain at every step. The key of this mode is"Taking project as the main line"; students do not passively listen to lectures but actively look up materials, study theories, and do experiments to complete tasks. The teacher is more like a coach, giving directions when the student gets stuck rather than filling in the answers. For example, if you want to talk about gears in a mechanical class, let students make a lifting device instead of talking about gear parameters alone. In the process, they will naturally understand how to match the gear with the most suitable speed. The benefit of learning in this way is that knowledge is no longer fragmented but becomes meaningful as it is pieced together through practical projects. In the hands-on process, students will continue to make mistakes, improve, and slowly learn to turn book knowledge into real skills [1].

2.2 The Background and Needs of Engineering Education Reform

In the past, training engineers was like teaching people to memorize manuals. Students learned a lot of formulas and charts, but when they arrived at the factory, they found that the machine models had been updated. The knowledge they learned was outdated, or the actual faults were complex and varied, unlike the “standard answers” in textbook exercises. Some students can learn circuit theory by heart but do not know whether to check the circuit or measure the voltage when encountering a short circuit in the workshop equipment. These problems force engineering education to be reformed. The enterprise does not need an "Examination master" but can quickly start flexible problem-solving engineers. For example, when developing intelligent devices, mechanical design, programming, and circuit debugging, which were originally taught separately, should be done simultaneously in practice. The traditional method of teaching subjects separately is like teaching someone to chop vegetables, stir-fry, and plate dishes but never having made a complete meal. Therefore, the key to education reform is to turn the classroom into an"Internship field," where students experience the real working state of engineers in real projects, facing time pressure, resource constraints and changing challenges, learn to plan as a whole and adjust your plans flexibly[2].

2.3 The Importance of Project-Driven Teaching Mode in Engineering Education

Project-driven teaching mode's greatest value is getting through the wall between school and workplace. For example, if students majoring in electrical engineering only do fixed wiring exercises in the experimental box, it is like learning to swim in a swimming pool. They will still choke if they are suddenly thrown into the sea. However, ask them to work together to develop an automatic watering system, from circuit design to programming to installation and debugging, and they will understand how the theory works: why do rain sensors fire by mistake? How do the delay settings in the program work with the mechanical switches? These questions, not taught in the classroom, can force students to integrate knowledge and even learn new skills outside the classroom. At the same time, real projects are full of surprises. Parts arrive late, budgets are over-budget, and designs are overturned repeatedly. These"Troubles" have instead developed resilience and a sense of teamwork. This learning process produces the engineers companies need better than mere exams: both know what to use and how and when to use it. After all, real engineering problems are never solved by opening a textbook.

3 The Dilemma of Project-Driven Engineering Education Curriculum Reform

3.1 The Matching Problem Between Teachers' Teaching Ability and Project Design

Project-based teaching requires teachers to have dual capacity: both to understand the theory of the subject and also to have the ability to convert knowledge into practical problems [3]. Many teachers have long been confined to the teaching mode within the framework of teaching materials and lack real project design experience. For example, in the"Intelligent Parking System" project, teachers will teach the principles of ultrasonic sensors in detail. However, there is a lack of guidance for the compatibility of license plate recognition algorithms and the stability test under different light conditions in practical applications. In the teaching process, teachers often misunderstand "Replacing practical requirements with theoretical tasks," such as overemphasizing the accurate calculation of circuit design parameters and ignoring the selection criteria of anti-interference measures in actual wiring. A more prominent contradiction is teaching inertia: when students use non-textbook methods to solve problems (such as using open-source code instead of traditional programming), some teachers cannot provide effective feedback because of their skill boundaries. Instead, they ask students to return to the steps they have already taken. The role change of teachers from"Knowledge imparters" to"Project coordinators" requires systematic practical training. However, most schools only provide short-term technical training, failing to establish a long-term mechanism for teacher-industry interaction.

3.2 Disconnect Between Course Content and Practical Engineering Needs

It is a common phenomenon that teaching lags behind the development of technology. In the automation field, for example, teaching cases often revolve around more than 20 kW motors, and the industry has gradually turned to the integrated control of micro-motors. This disconnect is due to multiple factors: textbook updating needs to be reviewed by the subject group and revised by the editorial board, and new technologies lag from the laboratory to the classroom by an average of 3-5 years. The school focuses on hard skills that can be quantified (such as programming grammar and Tester Operation) but lacks training carriers for soft power in engineering practice (requirement analysis and scheme trade-off). For example, in teaching hydraulic systems, students are skilled in calculating the pressure loss of the pipeline. However, they have not mastered the practical skills of quickly locating the leakage point through vibration and noise. As a result, graduates often spend months adapting to the logic of real work, and the thought of"Optimal Solution" in teaching projects needs to be adjusted to the path of"Feasible solution" considering material cost and maintenance period in practical engineering. The divergence between school grading criteria and project acceptance criteria (such as less than 10% of project documents and more than 30% of enterprise requirements) aggravates the ability training deviation[4].

3.3 Challenges of Student Development and Project-Driven Teaching

Students who have adapted to passive learning for a long time often face the problem of a lack of structured thinking at the beginning of the project. For example, in the logistics sorting robot project, students will be given priority to buy high-performance processing chips but do not plan the matching relationship between the load and the trajectory of the manipulator in advance, resulting in frequent rework in the later stage. The linear thinking mode of basic education training (clear problem → single solution → correct answer) is in direct conflict with the iterative characteristics of engineering practice (requirement change → multi-scheme test → dynamic optimization). Typical problems include overly idealistic stage goal setting (three days to complete the circuit board design, but no time for component procurement), poor risk prediction ability (not considering the impact of temperature and humidity on the sensor), and overreliance on faculty decision-making (teams choose to ask faculty directly rather than argue on their own when solutions diverge). The current evaluation system has not provided effective guidance for this. In some cases, teachers still consider whether the program can run as the main scoring standard so that students devote most of their energy to realizing functions, and only a small amount of time is spent on reliability verification. This tendency leads to hidden capacity deficits, where students complete multiple projects while in school without establishing the underlying logic of engineering thinking [5].

4 The Countermeasures and Optimization Path of Engineering Education Curriculum Reform

4.1 Improving the Integration of the Curriculum System and Teaching Content

The key of curriculum reform is to keep the learning content up to the industry's needs. Currently, many courses are out of touch with the actual project and need to be adjusted from the design source. Specifically, a"School-enterprise" curriculum renewal mechanism should be established: Every school year, a working group composed of enterprise technical backbones and teachers will adjust the curriculum framework according to the technological changes in the industry and eliminate outdated content, supplementing knowledge in emerging fields (such as charging management systems for new energy vehicles). The "Project-through" teaching method is adopted in the classroom, which connects the original scattered subject knowledge to the complete engineering scene. For example, the mechanical design course no longer explains the design specification of parts alone. However, it takes the"Intelligent warehouse handling robot" as the main line and individually embeds knowledge points such as material mechanics, transmission system, and sensor integration. At the same time, special class hours can be set aside every semester to invite enterprise engineers to explain the iterative logic of current mainstream technology tools to help students understand the underlying laws of industry technology evolution. The synchronous improvement of knowledge and ability is formed through the in-depth docking of the curriculum and the actual engineering chain.

4.2 Improving Teachers' Professional Ability and Project Design Ability

The upgrading of teachers' abilities requires the establishment of a long-term support mechanism. Schools should have a"Two-track rotation" system: every two years, teachers should be required to participate in at least one full production cycle of the project (such as the transformation of the smart factory production line), focusing on learning the engineering problem-solving process, and organize them into typical teaching cases. For example, after participating in the research and development of a sewage monitoring system, the teacher can design the course module "Development of multi-parameter water quality monitoring device" and restore the troubleshooting process in the real project. At the same time, an"Engineering teaching laboratory" will be set up on campus, with regular skill-strengthening training. For example, around the debugging scene of industrial robots, the actual working conditions are restored by using retired equipment donated by enterprises, and teachers are instructed to master practical skills such as parameter setting and fault code analysis. In the evaluation mechanism, the number of engineering teaching cases developed by teachers and the winning rate of students' project achievements in the industry competition are included in the evaluation indicators. The establishment of the interdisciplinary teaching team, by machinery, electronics, computers and other professional teachers to jointly design complex projects (such as smart agriculture greenhouse system), regular cross-evaluation of curriculum implementation effect, comprehensively enhance teachers' cross-disciplinary collaboration.

4.3 Strengthen the Cultivation and Evaluation Mechanism of Students' Practical Ability

Stages should construct the "Ladder" training system to cultivate students' practical abilities. The initial stage focuses on small tasks, such as setting up a “smart desk lamp development” task in an electronics course. In addition to soldering the circuit, it is also necessary to complete the entire production process, including creating a materials list and 3D modeling and printing the shell. In the intermediate stage, "Defect-guided" training is used. For example, in the UAV distribution project, the teacher sets the endurance limit, load fluctuation and other conditions in advance, and students are required to master the multi-factor balance method in repeated debugging. In the higher stage, such as graduation design, implementing the "Real problem do" mode directly adopts the technical improvement needs provided by enterprises (such as workshop mechanical arm energy-saving transformation) as the direction of the subject. Multi-dimensional indicators are established in the evaluation link: the feasibility of the technical scheme accounts for 50%, the rationality of cost accounting, the efficiency of team cooperation and the perfection of the risk plan each account for 15%, and the introduction of corporate mentors' scores accounts for 30% of the final score. At the same time, a personal capability growth profile should be established to continuously track students' data throughout the entire process, from program design to physical debugging, generate a monthly analysis report on capability shortcomings, and provide targeted training resources. Students ' engineering thinking transfer ability is strengthened through the whole chain of practice closed-loop design.

4 Conclusion

This paper points out the main problems in the current engineering education, such as the course content not keeping up with the development of technology, the teachers' lack of practical experience, and the students' lack of systematic practical training. Strengthening cooperation between schools and enterprises and adjusting teaching methods can significantly improve students' ability to solve practical problems. Therefore, the reform of engineering education needs to start from three aspects: the school cooperates with the technical personnel of the enterprise, adjusts the curriculum according to the industry change every academic year, increases the content of intelligent equipment maintenance and new energy technology, and eliminates the outdated knowledge; Teachers are arranged to go to enterprises to participate in real projects every year, and these experiences are transformed into teaching cases. From simple practical tasks to complex engineering projects, a phased training system is established, and enterprises are introduced to participate in assessment and evaluation. Through the continuous docking of education and industrial needs, engineering and technical personnel with real practical ability will be transported for social development.

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