Exploration and Practice of Case-Based Teaching Integrated with Project-Driven Teaching Model: A Case Study of the Course "Principles of Machine Vision Detection"

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Abstract: *Learning and mastering machine vision technology is one of the core competencies for university graduates' employment and entrepreneurship. China is the largest market for machine vision, and there is a talent gap of 9.5 million in the industrial AI field, represented by machine vision. Machine vision is a multidisciplinary, integrated technology that involves knowledge from multiple fields. Traditional teaching methods have significant limitations when faced with the rapid updates and high demands of this technology. This paper explores the reform of the teaching model by combining case-based teaching with project-driven methods in the course "Principles of Machine Vision Detection." Through the organic integration of case-based teaching and project-driven learning, the model aims to enhance students' practical skills, innovation abilities, and problem-solving capabilities. The paper focuses on analyzing the theoretical foundations, implementation paths, practical effects, and challenges of this teaching model, and proposes corresponding improvements based on the course's practical outcomes. The research results show that the integration of case-based teaching with project-driven learning has a significant impact on the teaching of "Principles of Machine Vision Detection." It enhances students' practical and innovative capabilities and their ability to collaborate in teams, offering valuable insights into cultivating innovative talents that meet national strategic needs.*

Keywords: *Case-Based Teaching; Project-Driven Learning; Teaching Model; Machine Vision; Curriculum Reform; Innovation Ability*

Introduction

Machine vision technology is a key branch of the intelligent manufacturing industry and an important manifestation of the deep integration of information technology and industrialization. China is the largest market for machine vision, with a talent gap of 9.5 million in the industrial AI sector, including machine vision. In the era of "Big Data, AI, Cloud, and Mobility," the challenge for Chinese universities is to cultivate high-level, urgently needed technical professionals and innovative talents who meet the demands of intelligent manufacturing.

However, traditional teaching models primarily focus on the delivery of theoretical knowledge, neglecting the cultivation of students' engineering practice and innovative thinking skills. This results in students lacking the ability to propose solutions to complex engineering problems. Therefore, how to cultivate students' engineering practice abilities, innovative thinking, and teamwork skills has become a key issue that higher education must address.

This paper aims to explore the teaching reform path through integrating case-based teaching with project-driven learning. By combining project-driven approaches with real-life case studies, this model seeks to enhance students' practical application skills in machine vision technology. Based on the characteristics and teaching requirements of the course "Principles of Machine Vision Detection," this paper attempts to establish a teaching model that improves students' practical abilities while also cultivating comprehensive qualities and innovation capabilities. At the same time, it explores the implementation effects, challenges, and countermeasures of this model in actual teaching, which has significant theoretical and practical implications.

1. Integration of Case-Based Teaching and Project-Driven Teaching Model

1.1 Theoretical Foundation and Practical Value of Integrating Teaching Models

Both case-based teaching and project-driven teaching models have important theoretical foundations and practical value in the field of education. Case-based teaching, originating from the teaching practices of Harvard Business School, primarily involves analyzing specific cases, allowing students to immerse themselves in real or simulated situations. Through exploring issues, analyzing contexts, and proposing solutions, students enhance their critical thinking, decision-making, and practical abilities. The theoretical foundation of case-based teaching mainly stems from constructivist learning theory, which emphasizes that learners actively construct knowledge through interaction with the external environment, rather than passively receiving information.

Project-Based Learning (PBL) originated in the United States in the 1970s and focuses on learning theory and skills by solving problems in actual projects. The PBL model emphasizes student-centered learning, stimulating students' interest and exploratory spirit through project tasks, while also cultivating their problem-solving abilities, teamwork skills, and interdisciplinary knowledge integration. Theoretically, project-driven teaching is closely related to task-driven theory, which highlights the process of learning being driven by practical tasks. Students achieve deep learning and hands-on experience through "learning by doing" [1].

The combination of case-based teaching and project-driven teaching effectively integrates the strengths of each model. Case-based teaching focuses on the analysis and solution of real-world problems, while project-driven learning cultivates students' comprehensive practical skills and innovation abilities through specific project tasks. The integration of the two models allows them to complement each other and achieve a seamless combination of theory and practice.

1.2 Organic Integration Path of Case-Based Teaching and Project-Driven Teaching Model

1.2.1 Case-Driven Project Task Design

Teachers can use real-world cases related to the course content as the core of the project tasks. Students are required to analyze the case and propose solutions based on the project requirements. For instance, in the course Principles of Machine Vision Detection, teachers can select industrial machine vision application cases, such as surface defect detection in industrial products, and design corresponding project tasks. Students would then need to complete system design and experimental operations based on the technical requirements and challenges presented in the case.

1.2.2 Case Discussion and Reflection in Project-Driven Learning

During the project implementation process, students can periodically review and discuss relevant cases, analyzing technical challenges and solution strategies. This not only helps students better understand the project tasks but also stimulates innovative thinking and enhances their problem-solving abilities through case discussions. For example, in designing a machine vision detection system, students can reflect on the advantages and disadvantages of different surface defect recognition algorithms, explore how to improve accuracy and efficiency, and thus refine the project implementation plan.

1.2.3 Organic Integration of Case Learning and Project Practice

To achieve the organic integration of case-based teaching and project-driven learning, students can first acquire theoretical frameworks through case studies and then deepen their understanding through project practice. In this process, students not only apply the theories they have learned but also adjust and optimize their design plans based on difficulties encountered during the project. For example, when studying and practicing an industrial product surface defect detection project based on machine vision, students must address real-world issues such as unclear imaging of defects and difficulty in identifying defect categories. Through in-depth analysis, they will complete system hardware selection, image acquisition plans, and defect recognition algorithm design, promoting further reflection on theoretical knowledge and enhancing their ability to solve complex engineering problems.

1.3 Implementation Strategies and Operational Framework of the Integrated Model

1.3.1 Clear Alignment of Teaching Goals and Content

The first task in implementing the integrated model is to clarify the teaching objectives. For the course

Principles of Machine Vision Detection, which covers core topics such as machine vision optical system design, micro-vision systems and micro-structure image measurement, binocular stereo vision system calibration, and visual measurement, teaching objectives should combine theoretical learning with practical operations. While mastering foundational theoretical knowledge, students must also focus on developing practical skills, problem-solving abilities, and innovative thinking.

1.3.2 Modular Course Design and Implementation

To better organize teaching activities, course content should be modularized. Each module should be centered around specific cases, with the content gradually progressing from simple to complex, guiding students through the entire process from theory to practice in a step-by-step manner.

1.3.3 Organic Fusion of Project Tasks and Case Analysis

The teaching process should be divided into different stages to achieve the organic integration of case analysis and project tasks. During the theoretical learning phase, case analysis helps students understand basic concepts and methods. In the project implementation phase, students practice through specific project tasks, verifying and expanding upon the theoretical knowledge they have acquired. Teachers should provide timely guidance and feedback based on student progress to ensure a smooth transition and deepen students' practical experience [2].

1.3.4 Diversified Evaluation System and Feedback Mechanism

In the implementation of the integrated model, the teaching evaluation should cover multiple dimensions, including students' mastery of theory, performance in project practice, teamwork, and innovation abilities. The evaluation system should include both formative and summative assessments. Formative assessments involve real-time feedback on students' project progress, case analysis reports, and similar assignments. Summative assessments include team presentations, individual defenses, and course reports. In team presentations, group members should closely collaborate to showcase the team's project results and test relevant performance indicators. During individual defenses, students should analyze and compare different project solutions, reporting to teachers and peers in a flipped classroom format using PowerPoint. The course report requires understanding the current state of research both domestically and internationally, referencing authoritative journal articles from the past five years, and emphasizing individual contributions. While there may be some overlap in the work of group members, the overlap should not exceed 30%, with a focus on highlighting the individual’s contributions within the team.

2. Challenges in Implementing the Integrated Case-Based and Project-Driven Teaching Model in the Course "Principles of Machine Vision Detection"

2.1 Challenges in Student Engagement and Motivation

First, the lack of proactive learning awareness. Although the integrated model emphasizes students' autonomy in learning and problem-solving abilities, some students remain accustomed to the traditional teacher-led approach and lack the motivation to actively think and explore problems. In the course, students face complex technical issues, especially when dealing with interdisciplinary topics such as hardware design, classical image processing, deep learning, and other multi-field knowledge. Due to a lack of confidence or interest, they may struggle to fully engage in case analysis and project tasks, leading to a decrease in participation.

Second, challenges and fears related to hands-on practice. Project-based learning requires students to not only understand theoretical knowledge but also apply it to specific project tasks. In the course, students need to master technologies such as image acquisition, processing, and analysis. Some students may feel intimidated or confused when tasked with combining engineering practice. Particularly in project work, when results do not meet expectations or they fall behind other students, feelings of frustration may arise, impacting both their participation and motivation to learn [3].

Lastly, the imbalance between teamwork and individual responsibility. Project-based learning relies on teamwork; however, in practice, some students may have low participation and depend on other team members to complete tasks, resulting in a "free-riding" phenomenon. This not only affects individual motivation but may also lead to an imbalance in knowledge transfer within the team, ultimately impacting the quality of project task completion.

2.2 Teacher Competence and Adaptability of Teaching Methods

First, the shift in teachers' roles. In traditional lecture-based teaching, the teacher primarily acts as a knowledge transmitter, but in the integrated case-based and project-driven model, the teacher's role needs to evolve into that of a guide, coordinator, and facilitator. Teachers must not only impart basic theory but also provide technical guidance and methodological support during case analysis and project implementation. This shift requires teachers to have strong teaching design skills and problem-solving abilities, enabling them to handle complex situations in the classroom. However, some teachers may not be able to adapt to this change in time, leading to insufficient guidance during the project implementation phase and ultimately affecting student learning outcomes.

Second, the flexibility and diversity of teaching content. The Principles of Machine Vision Detection course covers multiple disciplines, including optical imaging, image processing, mechanical design, machine learning, computer hardware and software, and pattern recognition. When implementing case-based and project-driven teaching, teachers need to flexibly adjust the content and methods according to students' varying needs and the specific circumstances of the projects. Balancing theory with practice, designing challenging yet appropriate project tasks based on students' capabilities, and finding the right balance in teaching various technical subjects are all challenges that teachers face [4].

2.3 Issues with the Adaptability of the Teaching Evaluation System

First, the disconnect between single evaluation criteria and comprehensive ability assessment. Traditional evaluation systems typically focus on students' mastery of theoretical knowledge, often relying on written exams or single-type tests. However, under the case-based and project-driven teaching model, students need to possess not only a solid theoretical foundation but also strong practical skills, innovation abilities, and teamwork capabilities. To better assess students' learning outcomes, the evaluation system should encompass multiple dimensions, including knowledge mastery, practical application, teamwork, and innovative thinking. As a result, a diversified course assessment approach needs to be established, but the existing evaluation system has not fully adapted to this requirement, causing the assessment results to fail to comprehensively reflect students' learning performance.

Second, the challenge of combining formative and summative assessments. Project-driven learning emphasizes repeated practice and continuous improvement throughout the process, but the current evaluation system is more focused on summative assessments, neglecting formative assessments. In the Principles of Machine Vision Detection course, students repeatedly iterate through experiments and project cycles to refine their solutions. Therefore, a comprehensive evaluation system that both reflects students' final achievements and evaluates their learning process is a significant challenge that the current assessment system faces.

3. Teaching Practice of the Integrated Case-Based and Project-Driven Teaching Model in the Course "Principles of Machine Vision Detection"

3.1 Cultivating Students' Teamwork and Autonomous Learning Abilities

First, fostering students' teamwork skills. In the Principles of Machine Vision Detection course, students are divided into small groups of 3-4 members, each tasked with different project assignments. The roles and tasks of each group member are arranged by the team leader, and the teacher evaluates and helps coordinate the division of labor to ensure the rationality and efficiency of the teamwork. Through task-driven projects, students must collaboratively solve practical problems such as the design, debugging, and algorithm optimization of machine vision systems. During this process, team members are required not only to leverage their individual strengths but also to collaborate through group discussions and collective decision-making to overcome technical challenges.

Second, stimulating students' autonomous learning abilities. Machine vision is an interdisciplinary field that integrates multiple areas of knowledge. Students must possess strong self-directed learning abilities to succeed in this course. Through the case-driven teaching design, students are required to proactively search for relevant information, conduct technical research, and engage in independent learning based on the needs of the project. For example, when designing a machine vision inspection system, students need to independently study relevant image detection schemes, image processing algorithms, and software platforms [5].

Lastly, cultivating students' problem-solving and innovative thinking skills. Project tasks not only require students to master basic techniques but also demand that they demonstrate innovative thinking. When dealing with real-world cases, students need to identify problems, propose preliminary solutions, and continuously refine their solutions through practical work. For instance, when addressing the identification of surface defects on steel plate products, students may encounter false defect issues caused by oxide skin interference, requiring them to innovate within their existing knowledge framework and propose targeted detection plans and optimize recognition algorithms.

3.2 Adjustments and Innovations in Teacher Roles and Teaching Methods

The teaching approach should shift from knowledge transmission to learning guidance. In traditional teaching, the teacher is usually the central figure, leading the delivery of knowledge and managing the pace of instruction. However, in the integrated case-based and project-driven teaching model, the teacher's role transitions to that of a guide who encourages students to learn independently and think critically, thus stimulating their interest in learning. Throughout the course, teachers guide students in analyzing real-world cases, helping them extract and analyze problems, and find solutions in the context of project tasks.

Given the differences in students' foundational knowledge and learning progress, personalized teaching and feedback mechanisms need to be innovated. Teachers must adopt individualized teaching strategies tailored to the learning needs of different students. For example, teachers can provide additional guidance to students who have a weaker foundation, helping them better grasp the basic system design and image processing skills. For more advanced students, they can assign more challenging project tasks that encourage deeper exploration and innovation.

3.3 Evaluation and Improvement of Teaching Effectiveness

First, integrating formative and summative assessments. In this course, teaching effectiveness should be evaluated through both the learning process and the final outcomes. Formative assessments are primarily conducted through progress reports, periodic achievements, and teamwork performance during the project implementation phase.

Second, establishing a multidimensional evaluation system. Traditional evaluation systems tend to focus on academic performance, while the case-based and project-driven teaching model requires a more comprehensive evaluation of students' multidimensional abilities, including technical skills, problem-solving abilities, teamwork, and innovative thinking. Therefore, the evaluation system should be designed to reflect these multiple dimensions. For example, evaluations can be based on the innovation of the project, the depth of problem-solving, the effectiveness of technical application, and the collaboration and communication among team members [6].

Conclusion

This paper explores and practices the integrated case-based and project-driven teaching model in the Principles of Machine Vision Detection course, revealing the advantages of this model in promoting students' autonomous learning, enhancing practical abilities, and cultivating innovative thinking. Through the organic combination of case analysis and project tasks in teaching practice, students can deepen their understanding of knowledge while solving specific problems and learn how to apply the skills they have acquired to complex engineering problems. Meanwhile, teachers continually adjust teaching strategies and methods, further improving teaching quality and effectiveness. Future research can explore how to meet the demands of emerging technologies, better decompose project tasks, design teaching cases, and cultivate innovative talents that align with national strategic needs.

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