



Research on Teaching System Reform of Computer Vision Under Emerging Engineering Education

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Abstract. Against the dual backdrop of the comprehensive advancement of Emerging Engineering Education and the rapid iteration of artificial intelligence technology, Computer Vision, as a core course bridging theoretical knowledge and engineering practice, is confronting a series of prominent issues, such as the disconnection between teaching content and the actual needs of the industry, the rigid and simplistic teaching model, and the inadequate evaluation system. This paper proposes a "three-layer and four-dimensional" curriculum teaching system reform framework. The "three layers" constitute a progressive knowledge chain, including the foundation layer, the core layer, and the application layer. The "four dimensions" represent multi-faceted training objectives encompassing knowledge, competence, quality, and innovation. This framework is specifically designed to bridge the gap between teaching content and industrial demands, and further enhance students' comprehensive engineering capabilities. Through dynamic content iteration, scenario-based case instruction, whole-process practical project design, and the establishment of a multi-dimensional evaluation system, this study proactively achieves in-depth alignment between curriculum teaching, industrial demands, and technological frontiers—effectively bridging the traditional gap between academia and industry. Practice has demonstrated that this system has increased the compliance rate of students' engineering practice capabilities from 42% (before the reform) to 89% (after the reform), providing valuable references for the reform of similar courses under the background of Emerging Engineering Education. Future research can further optimize the framework by integrating more cutting-edge industrial scenarios and intelligent evaluation tools.

Keywords: Emerging Engineering Education, Computer Vision, Teaching System Reform, Engineering Practice

1 Introduction

As a key driver of higher education reform, Emerging Engineering Education places emphasis on interdisciplinary integration, practical innovation capabilities, and industry service orientation, proactively propelling the transformation of engineering education toward the cultivation of interdisciplinary, innovative, and application-oriented

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talents. although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow. As a core technology in the field of artificial intelligence Computer Vision has been deeply integrated into key domains including industrial inspection, medical diagnosis, autonomous driving, and intelligent security—thus emerging as one of the core practice-oriented courses in talent cultivation for Emerging Engineering Education, which closely aligns with industrial development demands.

As a local undergraduate university, the college launched the new Artificial Intelligence program in 2020, aiming to cultivate interdisciplinary technical talents who can serve Guizhou's regional economic development. In the teaching of Computer Vision courses, local undergraduate institutions face numerous prominent challenges: first, students' foundational knowledge varies greatly, with a relatively high proportion of those lacking strong programming skills; second, the classroom teaching content is outdated, focusing primarily on traditional image processing algorithms, while insufficiently covering cutting-edge technologies such as visual large models (e.g., ViT, SAM, TensorRT, and CLIP)—the redundant mention of SAM in the original text has been optimized; third, most teaching cases are simplified academic scenarios, lacking practical cases integrated with Guizhou's local characteristic industries such as big data and intelligent agriculture; fourth, the teaching model remains theory-centered, with practical sessions accounting for only 25% of the total class hours and lacking systematic practical design and guidance; fifth, the course evaluation system emphasizes assessments of knowledge acquisition, neglecting the evaluation of students' comprehensive competencies such as engineering practice capabilities, innovative awareness, and teamwork skills.

These aforementioned issues have directly resulted in a significant disconnect between the knowledge students acquire at school and the practical application requirements of their roles, making it difficult to meet enterprises' urgent demand for interdisciplinary technical talents. Taking the artificial intelligence major at local universities as a pilot, this paper constructs a "three-layer and four-dimensional" teaching system. This not only enriches the localized theoretical achievements of emerging engineering curriculum reform but also provides a more adaptable new practical paradigm for the knowledge integration, competence development, and quality improvement of interdisciplinary courses in local universities.

2 Related Work

In recent years, domestic universities have gradually advanced the reform of computer vision courses, with some "Double First-Class" universities taking the lead in introducing advanced approaches such as the OBE concept and project-based teaching. However, on the whole, most reforms are still confined to the partial optimization of individual teaching links and have not yet achieved a systematic restructuring of curriculum content, teaching models, and evaluation systems. Meanwhile, the practical constraints

of relatively weak academic foundations among students in local universities and limited supply of industrial resources are often overlooked in the reform process, which restricts the effectiveness of the reforms in practice.

Chen et al.[1] proposed a local industry demand-oriented approach to advancing teaching reform across dimensions such as the systematic restructuring of curriculum systems, in-depth university-enterprise collaborative talent cultivation, dynamic case development, and the construction of multi-dimensional evaluation mechanisms. They explored and developed a distinctive teaching model characterized by "industry demand-driven, project task-led, and competency-based hierarchical training." He et al.[2] takes the Computer Information Technology course as the carrier, designs and implements a gamified teaching plan, and conducts a controlled experiment by setting up an experimental class (adopting gamified teaching) and a control class (adopting traditional teaching). It systematically tests the practical application effect of gamified teaching in improving students' academic performance and stimulating their learning motivation.

In overseas computer vision course teaching, great emphasis is placed on the in-depth integration of engineering practice and cutting-edge technologies, with top universities such as Stanford University and the Massachusetts Institute of Technology (MIT) in the United States being particularly representative. They closely align curriculum teaching with research projects and actual enterprise needs, adopt the core teaching model of "case-driven + project-oriented," and focus on cultivating students' comprehensive abilities in solving complex engineering problems. However, the overseas curriculum system has weak adaptability to the academic foundations of students in local universities in China and the actual needs of localized industries, making it difficult to directly transplant and learn from. A meta-analysis of relevant research data on the impact of active learning on the STEM (Science, Technology, Engineering, and Mathematics) academic performance of Asian students has found that active learning exerts a significantly positive effect on their STEM academic performance[3].

Demartini et al.[4] proposed the development of an easy-to-use artificial intelligence (AI) learning dashboard, which aims to provide robust support for teachers and principals who strive to improve the quality of education in complex and diverse school social environments. Isaeva R et al.[5] examined the impact of mainstream educational platforms and adaptive technologies on learning processes and systematically evaluated their actual application effectiveness across diverse educational contexts. The research findings indicate that adaptive platforms not only significantly enhance the accessibility and flexibility of learning but also can provide precise and personalized feedback to learners through real-time data analysis. If diverse teaching elements such as flipped classroom, self-regulated learning, and microlearning are organically integrated into adaptive learning strategies, the innovative teaching model of adaptive learning will exert a significantly positive impact on the optimization of students' learning processes and the improvement of their comprehensive competencies[6].

Ling, Hsiao-Chi et al.[7] proposed a web programming learning recommendation system, which aims to provide students with precise and personalized guidance as well as a step-by-step and hierarchical learning plan. It helps learners continuously gain a

sense of accomplishment during the learning process, thereby establishing solid learning self-confidence and ultimately effectively improving their learning outcomes. In the field of engineering education, Challenge-Based Learning (CBL), as an innovative teaching method, can effectively drive students to actively participate in real-world engineering contexts, directly face and solve complex social and engineering challenges[8]. Khlaif et al.[9] pointed out that faculty professional development, technical support, and infrastructure construction are key contextual factors influencing the teaching application of XR technology, and they play a positive enabling role in its implementation and promotion. Meanwhile, social support, as well as the core characteristics of XR technology itself—such as interactivity, visualization, and simulation—also play an indispensable and important role in the teaching practice of XR technology.

3 Teaching System Reform Plan

Guided by the emerging engineering education philosophy of "student-centered, output-oriented, and continuous improvement", we have established a "three-tier stepped" knowledge system and a "four-dimensional comprehensive" competency development system.

3.1 Construction of a "Three-Tier" Stepwise Knowledge System

Focusing on fostering the underlying capabilities of core technologies, we adopt the "hierarchical teaching + foundational supplementary courses" model to facilitate the precise connection between basic knowledge points and core technologies. Integrating linear algebra with convolution operations, and probability and statistics with model optimization, we design the "Correlative Experiment on Matrix Operations and Convolution Principles" to specifically address students' weaknesses in mathematical foundations. Centered on Python, we integrate practical modules such as engineering applications of OpenCV and Numpy array operations, paired with basic tasks like "image reading - filtering - saving" and advanced tasks such as "target coordinate extraction".

We implement the "trinity" teaching model integrating "principle derivation, technical selection, and regional cases", and construct a closed-loop competency chain encompassing "algorithm understanding, application decision-making, and regional adaptation". We focus on dissecting the mathematical modeling and implementation logic of core algorithms, including the loss function construction of the YOLO algorithm and the principle of the attention mechanism in the ViT model, while synchronously supporting practical tasks such as "reproducing a simplified version of YOLOv8 based on PyTorch". We design application scenarios based on actual industrial needs and elaborate on the logic of algorithm selection under different scenarios — for example, tea garden pest detection is a small object detection task, so YOLOv8 is appropriately selected; real-time recognition via traffic cameras emphasizes real-time performance requirements, making YOLOv5 the preferred choice. One-third of the core content is updated each semester, with new modules such as "Visual Large Model Fine-tuning" and

"Remote Sensing Image Analysis" added, and enterprise mentors are invited to deliver lectures on cutting-edge technologies.

Centering on the dual cores of "full project lifecycle + regional industry", we design the teaching content to fully cover key links such as requirement analysis, technical scheme design, code development, and deployment testing, and have developed 3 types of regionally characteristic comprehensive projects as the assessment content for students' courses.

- Intelligent Recognition System for Tea Garden Pests and Diseases: It requires a recognition accuracy of $\geq 92\%$ and is compatible with edge device deployment. Students are required to tackle engineering challenges unique to mountainous tea gardens, such as "leaf occlusion" and "complex background interference".
- Karst Landform Segmentation System for Remote Sensing Images: Taking "landform type classification accuracy $\geq 88\%$ " as the core target, we ensure its precise realization.
- Intelligent Hidden Danger Inspection System for Smart Industrial Parks: With "safety helmet recognition rate $\geq 95\%$ and response time $\leq 0.8s$ " as the core requirements, we ensure the system is practical and reliable.

3.2 "Four-Dimensional" Multi-Dimensional Competency Development System

A blended teaching model is adopted: online, micro-courses, literature materials such as YOLOv8 paper interpretation are provided via Chaoxing Xuexitong for independent study; offline, in-depth seminars between teachers and students are organized to promote the improvement of theoretical cognition and thinking abilities. An additional course titled "Advanced Topics in Visual Technology" is offered to guide students in delving deeply into high-quality papers from top-tier conferences such as CVPR and ICCV, completing tasks of in-depth study and report writing. Every semester, the teaching content is dynamically adjusted in conjunction with technological iteration trends and actual industrial needs to ensure that the knowledge system is updated in sync with cutting-edge technologies and industry applications.

To address the three key competency weaknesses of students, we on the one hand conduct practical training in code refactoring and performance optimization, and on the other hand set up edge device deployment tasks, such as accelerating models with TensorRT and deploying them to Jetson Nano — to comprehensively consolidate their hands-on skills.

In practical projects such as face recognition and surveillance video analysis, combined with relevant data security regulations, in-depth discussions are conducted on core ethical issues including privacy protection and data security, and students are required to write special ethical analysis reports. A group collaboration model with 3-5 members is adopted. Students are required to submit detailed division-of-labor logs and collaborative summary reports, aiming to effectively enhance their teamwork and communication skills.

We actively promote students to apply for college students' innovation and entrepreneurship projects and participate in the entire process, provide professional guidance for them to design commercialization schemes such as vision-based agricultural product quality inspection equipment, and vigorously encourage students to participate in key competitions including the National College Student Robotics Competition and the National Undergraduate Mathematical Modeling Competition, so as to enhance their comprehensive literacy.

3.3 Multi-Dimensional Evaluation System Construction

Centering on the teaching reform system of this course, an evaluation index system consisting of eight items has been constructed, with specific contents shown in Table 1.

Table 1. Evaluation Indicators

Evaluation Item	Evaluation Method	Weight Ratio	Compliance Rate Before Reform	Compliance Rate After Reform
Theoretical Assessment	Final Written Exam (including algorithm principles and cutting-edge cognition)	15%	41%	82%
Paper Reading Report	Report Quality + Defense Score	10%	38%	93%
Project Scheme Design	Scheme Rationality + Accuracy of Technical Selection	15%	35%	81%
Code Review	Code Standardization + Performance Optimization Effect	15%	42%	89%
Team Collaboration Log	Rationality of Division of Labor + Collaboration Contribution	10%	58%	92%
Technical Ethics Defense	Depth of Ethical Analysis + Compliance Awareness	5%	32%	85%
Technological Optimization Achievements	Number of Optimization Points + Extent of Effect Improvement	15%	18%	67%
Achievement Transformation / Competition Achievements	Scheme Feasibility + Competition Award Level	15%	5%	32%

We reduced the proportion of the final written exam from 60% (before the reform) to 15%, with the assessment content focusing on core theoretical knowledge. Meanwhile, we increased the weight of process-oriented evaluation from 40% to 55%. By adopting a combined model of weekly quizzes and phased assessments, we conduct comprehensive evaluations of key links such as paper reading, team collaboration, and code review. Finally, we have strengthened the evaluation of comprehensive project

implementation, including the scheme design, technological optimization, and achievement transformation of students' projects.

4 Project Implementation Effectiveness

4.1 Significant Enhancement of Students' Core Competencies

A qualitative leap has been achieved in students' self-directed learning capabilities: the proportion of students in the experimental class who independently complete inquiry tasks before class reaches 90%, showing a notable increase compared with 40% in the control class; the excellent rate of paper reading reports hits 65%, far exceeding the 22% level of the control class, with a significant gap.

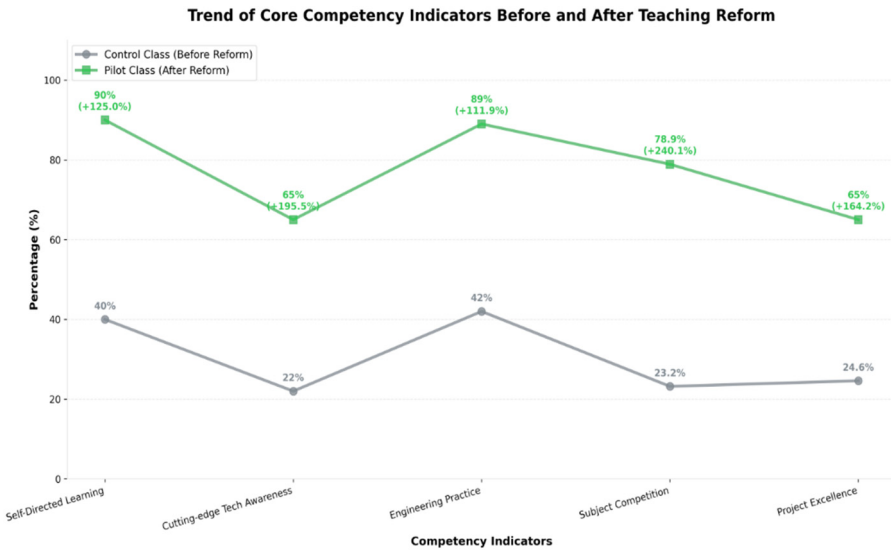


Fig. 1. Comparison of Competency Indicators between the Pilot Class and the Control Class of the Artificial Intelligence Major

The engineering practice capabilities have achieved a substantial improvement: 89% of students in the experimental class can independently complete the entire process of "algorithm design - model deployment", while only 42% of those in the control class can do so, showing a significant advantage.

The innovative capabilities have also achieved a breakthrough: 30 students in the experimental class participated in discipline competitions (compared with 10 in the control class), with a participation rate of 78.9%, far higher than the 23.2% of the control class. We present the above data as a line chart in Figure 1.

4.2 Comprehensive Optimization of Teaching Quality

The ability to connect knowledge systems has been significantly enhanced. The "knowledge connection gaps" reported by students in the pilot class have shown a distinct downward trend compared with before the reform, and the learning bottleneck rate has dropped sharply from 62% to 21%. This fully verifies the effectiveness of the reform in breaking down knowledge barriers and improving learning continuity.

At the level of teaching resource development, a case library covering multiple real application scenarios and supporting practical project plans have been established. This set of resources can be directly adapted to the teaching of the next cohort of the Artificial Intelligence program, providing concrete and implementable teaching support for the curriculum's practical sessions.

A remarkable breakthrough has been achieved in course satisfaction. Both the satisfaction level and teaching evaluation scores of the "Computer Vision" course among students in the pilot class have seen substantial improvements compared with those before the reform, which fully reflects the continuous optimization of the adaptability between the curriculum content, teaching mode and students' learning needs after the reform.

5 Conclusion

The "Three-Layer and Four-Dimension" teaching system, constructed with the Artificial Intelligence program of local universities as a pilot, has successfully addressed the three core challenges of the "Computer Vision" course in local institutions—namely, students' weak foundational knowledge, inadequate industry alignment, and limited practical resources—through the phased reconstruction of knowledge systems, multi-dimensional coverage of training objectives, innovative design of teaching models, and full-process optimization of evaluation systems featuring process quantification. Practical verification indicates that this teaching system not only significantly enhances students' engineering practice capabilities and innovative awareness but also synchronously promotes the two-way improvement of teachers' teaching competence and industry service capacity, providing a replicable and promotable practical paradigm and reference path for the reform of emerging engineering courses in local universities.

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