

Exploration of Teaching Reform in Applied Undergraduate Courses Driven by Generative AI: Taking the Course of “IoT Machine Vision” as an Example

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Abstract: Addressing the key challenges in the teaching of engineering courses in applied undergraduate universities, including high entry barriers, difficult engineering practice, and weak innovation ability, this paper takes the IoT Machine Vision course as the case study, proposes a new model of teaching reform based on the AIGC+CDIO concept. This model integrates Artificial Intelligence Generated Content (AIGC) tools into the Conceive-Design-Implement-Operate (CDIO) process. Through conducting an empirical study on the teaching project of Intelligent Detection of Safety Helmet Wearing at Construction Sites, which indicates that, this model effectively lowers the technical barrier to coding. Students can transfer their focus from low-level code debugging to algorithm logic design and engineering applications. This model substantially enhances students' competency to solve complex engineering challenges and cultivate their digital literacy.

Keywords: Generative AI; Internet of Things Engineering; Machine Vision; CDIO; Teaching Reform; Safety Helmet Detection

1. Introduction

With the rapid development of artificial intelligence technology, especially the widespread adoption of Artificial Intelligence Generated Content (AIGC) represented by DeepSeek, traditional engineering education encounters enormous challenges and opportunities [1]. In the Internet of Things (IoT) Engineering program of application-oriented undergraduate universities, courses such as Machine Vision or Deep Learning Applications are undoubtedly core courses yet challenging subjects. There are two main problems in traditional teaching practice. Firstly, the high technical requirement inhibits students' desire to

learn. When studying frameworks like YOLO and TensorFlow, students usually struggle with issues like complex environment setup, dataset format conversion, and low-level coding, etc. Substantial time during class is consumed on configuring the operation environments and debugging bugs, and thus students lose interests long before approaching the core algorithmic logic [2]. Secondly, engineering practice usually disconnects with industry demands. Owing to the absence of real-world scenarios with complex conditions such as Smart Agriculture or Industrial Quality Inspection, traditional experiments are usually based on verification (e.g., MNIST handwritten digit recognition). Consequently, although students gain the ability to execute the demo code, their limited efficacy in processing real-world and non-standard data has also become prominent.

This paper aims to explore how to use AIGC tools as intelligent teaching assistant and code partner, to transform the teaching process of the IoT Machine Vision course. Through human-machine collaboration, the goal is to cultivate more application-oriented innovative engineering talents with digital literacy [3].

2. New Paradigm for Engineering Course Teaching Based on AIGC + CDIO

CDIO (Conceive, Design, Implement, Operate) is an internationally recognized engineering education model [4]. Based on traditional CDIO, this study introduces AIGC as a key supporting tool to establish the new teaching model AIGC+CDIO. In this reform of course teaching, generative AI primarily functions as a supporting tool to facilitate teaching activities. The objective of this reform does not imply to replace teachers with AIGC in teaching, on the contrary, AIGC serves as an assistant to conduct course design and learning process, guiding students toward more efficient learning. With

utilizing generative AI tools appropriately aligning with the coach of teachers, students complete foundational tasks such as data retrieval, solution conception, and problem analysis, etc[5]. Therefore, they devote greater proportion of energy on understanding engineering principles and optimizing designs. The essential point is that AI provides assistance and human control the logic. The detailed construction of this model can be shown in Figure 1.

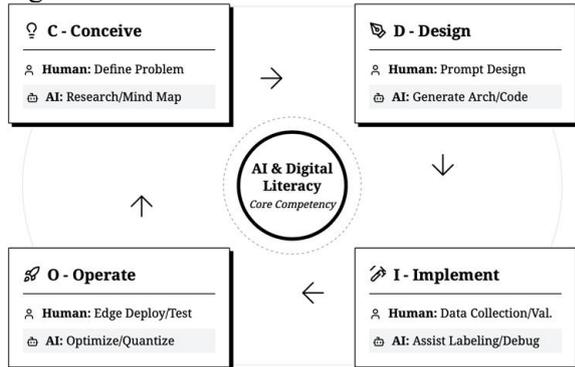


Figure 1. Construction of IoT Teaching Model Based on AIGC+CDIO

In the AIGC+CDIO based IoT course teaching model, C (Conceive) refers to scenario-based AI discussion. Teachers introduce problems existing in real industry (e.g., frequent safety accidents at construction sites), and students leverage large AI models to start technical research and rapidly prototype mind maps, then take the edge violation detection based on machine vision as the technical route. D (Design) refers to prompt programming and architecture building. Students do not need to write neural network structures from the ground up. They train AI to generate code based on standard training scripts and data preprocessing through specific Prompts [6]. The teaching focus transfers from grammar memorizing to prompt engineering and code review. I (Implement) refers to debugging and optimization through human-machine collaboration. When issues like over fitting or missed detections arise during model training, students consult AI for solutions (e.g., adding data augmentation strategies), and utilize AI-assisted labeling tools to accelerate dataset creation. O (Operate) refers to on-device deployment and closed-loop validation. This step is to convert and deploy the trained model to embedded devices like Raspberry Pi for testing in simulated scenarios. To more precisely illustrate the changes before and after the reform, the comparison of traditional

teaching model and proposed AIGC+CDIO model in detail is shown in Table 1.

Table 1. Comparison of Traditional Teaching Model and Proposed AIGC+CDIO Model

Dimension	Traditional Teaching Model	AIGC+CDIO Teaching Model
Teaching Focus	Memorizing syntax, setting up environments, calling APIs	Designing logic, prompt engineering, optimizing models
Code Writing	Students manually write every line of code, low efficiency	AI generates basic code, humans are responsible for review and assembly
Data Source	Public datasets, single scenarios	Collecting real scenarios (e.g., construction sites), AI-assisted annotation
Teacher-Student Roles	Teacher lectures, students imitate	Teacher guides, AI assists, students explore
Assessment Orientation	Focus on code execution results (result-oriented)	Focus on problem-solving process and human-machine collaboration (process-oriented)

Aligned with applied undergraduate talent development objectives, this course teaching reform prioritizes engineering practice, and uses project-based teaching method to guide students to complete learning tasks in real or quasi-real engineering contexts. The introduction of generative AI tools helps lower the technical threshold for project implementation, enhance the feasibility of teaching activities, and create advantages for students to engage in entire engineering workflows.

3. Implementation Paths for Empowering IoT Machine Vision Course Teaching with Generative AI

This chapter discusses the specific implementation process of AIGC+CDIO model in the IoT Machine Vision course, through the Detection of Safety Helmet Wearing at Construction Sites project. We have shifted our teaching focus from purely technical implementation to fostering the engineering mindset and enhancing students' problem-solving skills, aiming to assist students to solve complex engineering problems with greater proactivity and innovation. The detailed process of teaching implementation is illustrated in Figure 2.

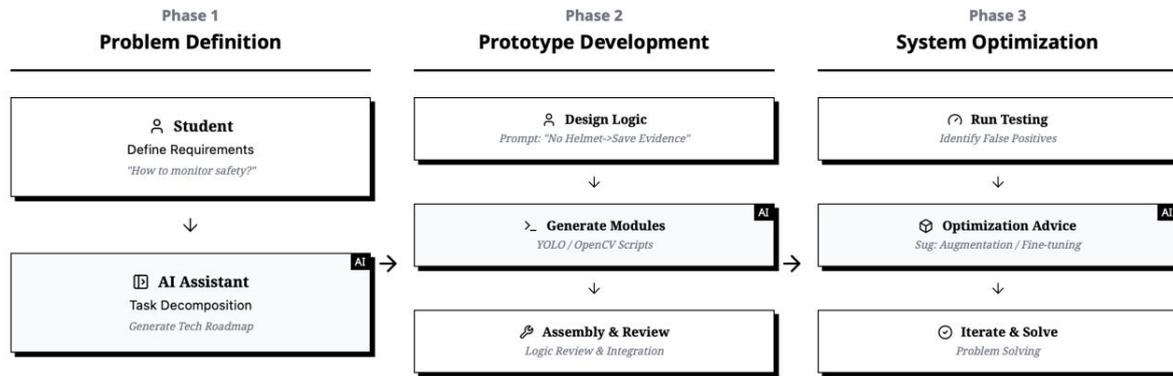


Figure 2. Implementation Process of Safety Helmet Detection

3.1 Problem-Oriented Reconstruction of Teaching Content

In traditional IoT machine vision courses, teachers usually deliver technical knowledge, such as programming syntax and library function calls, chapter by chapter, following the textbook, etc. However, this teaching approach usually confines students to purely technical skills learning, which fails to effectively apply the learned knowledge to practical problems. Especially for courses involving complex engineering technologies, students usually find it challenging to perceive the whole engineering application underlying a single technology, resulting in fragmented knowledge, which impedes the development of students' comprehensive abilities.

To address this issue, we restructured the teaching content into a problem-oriented format, and designed a complex and authentic engineering challenge: How to monitor safety violations on construction sites in a cost-effective manner. This issue not only aligns closely with practical needs, but also covers technical contents including image recognition and data processing, enabling students to apply technical knowledge to real-world contexts. By task-driven, students design the intelligent detection system, and rapidly acquire datasets of construction site by leveraging AI tools, without having to write complex web scraping code themselves. Through this iterative process, students develop a deeper conceptual understanding that, high-quality data holds greater significance than the code itself, which lays a solid foundation for their subsequent studies. This approach lowers the technical barrier, furthermore, it strengthens students' application abilities in authentic engineering challenges.

3.2 Human-Machine Collaborative "Dual-Teacher" Classroom Teaching Model

The implementation of this teaching model in the classroom has transformed the traditional teaching approach of teacher demonstration and student imitation, and has established an entirely new classroom ecosystem of teacher guidance, AI assistance, student inquiry [7]. The core of this model lies in achieving human-machine collaboration, which enables students to leverage the advantages of AI tools for independent learning and problem-solving, align with the traditional guidance of teacher[8].

In the human-machine collaboration teaching model, AI, as the role of intelligent teaching assistant, provides students with real-time learning support. When students encounter problems during programming or algorithm implementation, they will firstly turn to AI tools for assistance. AI is capable of providing not only specific code snippets, and also the explanation of underlying technical logic, to assist students in understanding how to transfer theoretical knowledge to practical application. This approach provides personalized tutoring support for each student, and significantly improves students' learning efficiency and autonomy. Meanwhile, teacher's role has shifted to chief designer, who guides students to engage in system design and critical thinking, rather than confines to grammatical error correction. This approach not only facilitates a deeper comprehension of the course content for students, but also enhances their problem-solving ability when encountering complex engineering challenges, leading them to gradually master the skills to convert vague business requirements into coherent technical logic.

3.3 Transformation of Teaching Focus from Lower-Order to Higher-Order Thinking

In traditional courses, students spend 80% of their time troubleshooting low-level issues such as spelling errors or environment configuration. But with the adoption of AIGC, there has been an essential transformation in teaching focus [9]. Owing to that AI rapidly generates the basic code, students can spare more time to contemplate the integration of hardware and software. They began to concentrate on how to make the recognition algorithm operate smoothly on embedded devices with limited computing power, as well as how to enhance response performance of the system. The initial version of the system frequently suffers from false positives or instability. Teachers guide students to apply AI in analyzing the root causes of false positives, such as illumination variations or occlusions due to viewing angles, thus design optimization solutions. Students are no longer preoccupied with whether the code can run without errors, but rather focus on

practical applicability of the system. This transformation from micro-level syntax to macro-level logic, significantly enhanced students' systematic thinking in engineering, and empowered them to view the project from a macro perspective.

4. Reform of the Assessment Framework Empowered by Generative AI

4.1 Process-Oriented Assessment Framework

To adapt to the teaching reform which is AIGC-driven, the course assessment frameworks have experienced substantial transformation. Given that the code can be entirely generated by AI, we no longer rely solely on final-term coding assignments for assessment, but establish multi-dimensional process-oriented assessment criteria [10], the detailed assessment criteria framework is presented in Table 2.

Table 2. Process-Oriented Assessment Criteria Framework Based on Digital Competence

Primary Indicator	Secondary Indicator	Weight	Assessment Content	AIGC Assistance
Prompt Engineering Skills	Questioning Quality	15%	Clarity, logic, and number of iterations of prompts	Ability to precisely guide AI to generate required code
	Error Correction	15%	Ability to identify errors in AI-generated code	Code review and logic debugging
Engineering Implementation Effectiveness	Recognition Accuracy	20%	The mAP@0.5 of the model on the test set	Performance metrics of the final model
	Hardware Integration	20%	Response speed and stability of the alarm system	Debugging capabilities for software-hardware integration
Complex Problem Solving	Debugging Log	20%	Git submission records, error troubleshooting process records	Pathways to solve errors using AI
	Team Collaboration	10%	Group division of labor and document writing	Utilizing AI to assist in writing documents

4.2 Teaching Effectiveness

After one semester of teaching reform practice, a comparative analysis of data from two parallel classes (teaching reform class and traditional class) has been conducted, we achieved significant improvements. The detailed comparison of teaching effectiveness between the two classes is shown in Figure 3.

As shown in Figure 3, the line chart on the left displays a pronounced scissors gap. Along with the integration of AIGC tools, students are no longer troubled by low-level coding issues, the proportion of students suffering coding anxiety dropped sharply from 75.6% to 18.2%, while the project completion rate surged from 24.4% to 89.1%. This dual effect of decrease in the

former and increase in the latter provides strong validation of AIGC's critical role in eliminating students' technical anxiety. Meanwhile, the quality of engineering practice has been steadily improved, and the model's average precision has increased by 13.8%, both indicate that students reallocated the time saved on coding toward the cultivation of advanced competencies, including data cleaning and parameter optimization. Moreover, the bar chart on the right shows that the number of awards in academic competitions achieved a 200% increase from 2 to 6, verifying that the model extends beyond large-scale popularization teaching, and stimulates more effectively the potential of high-achieving students, propelling the rise of generations of outstanding innovative talents.

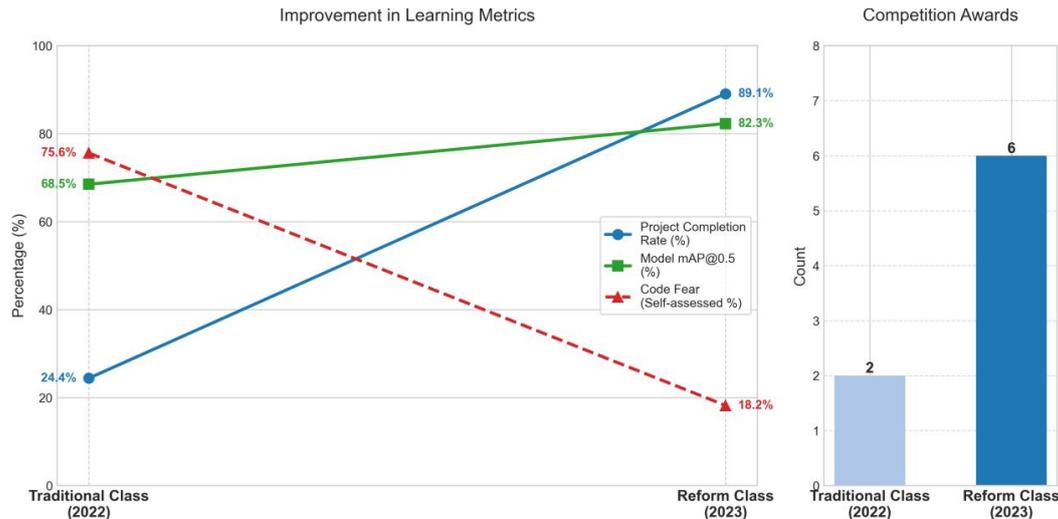


Figure 3. Teaching Effectiveness Comparison: 2022 (Traditional Class) vs. 2023 (Reform Class) 24-31.

5. Conclusion

The teaching reform practice exemplified by the IoT Machine Vision course demonstrates that, the emergence of generative AI has not diminished the role of teachers but rather imposes higher demands upon them. Teachers' role in teaching transforms from knowledge disseminators to project architects plus thinking facilitators. Generative AI, as a teaching supporting tool, has a positive promoting effect in the teaching of applied undergraduate courses. By reasonably guiding students to use generative AI tools, it promotes to reduce the learning barriers, strengthen the engineering practice orientation, and effectively cultivate students' core competence of using tools to solve complex problems. In subsequent teaching reforms, we will further explore the deep integration of generative AI and course teaching, improve the teaching design and assessment mechanism, and prevent students from growing overly reliant on the tools. Overall, this model provides a new approach for the digital transformation of applied undergraduate universities.

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