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# Intelligent Scheduling-Driven Co-Creation Manufacturing Closed-Loop Reform Oriented by Industry-Education Integration

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**Abstract:** In the context of multidisciplinary integration, universities must bridge the gap between classroom teaching and industrial practice to achieve deep industry-education integration. Currently, university teaching faces issues such as misalignment of curriculum with industry needs and low efficiency in resource allocation. This paper proposes a closed-loop teaching reform model oriented by industry-education integration, built upon an intelligent course scheduling system for academic resources and a university-enterprise co-creation manufacturing platform. Through AI-driven smart scheduling to optimize on-campus course and resource allocation, and by introducing real enterprise projects into the teaching process, a closed-loop flow from classroom to practice and back is established. We detail the closed-loop teaching process and system architecture, which enable data-driven teaching optimization and collaborative innovation between universities and enterprises. This approach provides a new idea for talent training reform under a multidisciplinary background.

**Keywords:** industry-education integration; intelligent scheduling; university-enterprise collaboration; co-creation manufacturing; Teaching closed-loop

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## 1. Introduction

A new round of technological revolution and industrial transformation is accelerating, with emerging technologies such as artificial intelligence and digital manufacturing profoundly influencing fields like engineering and design. Talent cultivation in higher education must keep pace, emphasizing both theory and practice in a multidisciplinary context to train compound talents who possess creative design skills and understand industrial applications [1]. There has long been a disconnect between traditional university teaching and industrial practice: universities focus on classroom theory, while enterprises focus on tangible project outputs. Lacking an effective collaboration mechanism, graduates struggle to promptly meet industry needs. This contradiction is especially pronounced in interdisciplinary fields such as engineering technology and art design, and it urgently requires industry-education integration to resolve.

The "Triple Helix" model proposed by Henry Etzkowitz (USA) and Loet Leydesdorff (Netherlands) stresses that close collaboration among universities, industry, and government is key to building an innovative ecosystem [2]. The German scholar Henning Kagermann noted that digital transformation has brought a new paradigm of value creation in industry [3]. Globally, various practices of industry-education integration have emerged. For example, Germany's Fraunhofer Society efficiently translates research outcomes into practice through academia-industry collaboration, demonstrating the great

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value of such synergy [4]. In the United States, the Manufacturing USA initiative established a network of advanced manufacturing innovation institutes, fostering deep cooperation between universities and enterprises in advanced manufacturing. These explorations indicate that a demand-driven collaborative innovation mechanism can significantly improve the efficiency of translating technological results into real-world outcomes [5].

## **2. Current Problems and Overall Reform Framework**

### *2.1. Pain Points in Traditional Teaching and University-Enterprise Collaboration*

In the traditional talent training model, curriculum planning is often disconnected from industry developments. Course content updates slowly and fails to cover the latest technological and design trends. Students' practical training is limited to on-campus lab courses and lacks experience in real projects, resulting in insufficient development of innovation abilities. Enterprises require fresh ideas and talent support during product innovation, but creative outputs from universities and student projects seldom find pathways into industry, meaning that resources on the academic and enterprise sides have not formed a synergistic whole [6].

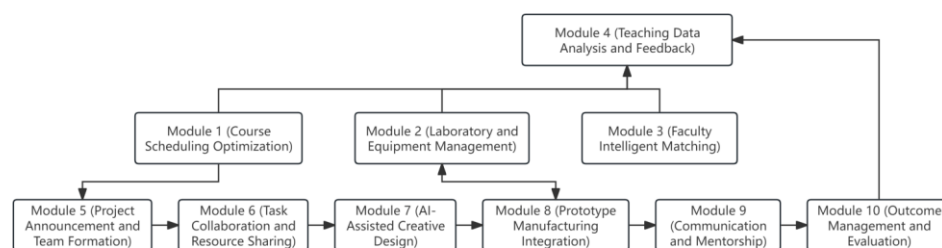
In terms of teaching management, the allocation of various resources is inefficient: class scheduling conflicts occur frequently, some practical teaching spaces remain underutilized while others are insufficient, and there is a lack of data monitoring and timely feedback mechanisms in the teaching process, making it difficult to detect and correct quality issues promptly. Furthermore, due to the absence of a robust industry-education collaboration mechanism, university-enterprise projects rarely integrate into regular teaching; they often end up as superficial short-term internships or competitions that cannot be sustained or yield substantial outcomes. These pain points indicate that higher education urgently needs to adopt data-driven management optimization and long-term collaborative mechanisms to improve resource utilization efficiency and the depth of academia-industry cooperation [7].

### *2.2. Data-Driven Closed-Loop Reform Strategy for Industry-Education Integration*

The reform aims to embed a closed-loop industry-education collaborative process into the existing teaching system, using industry needs as the driver and data to fuel continuous teaching optimization. Real enterprise projects are introduced into the curriculum as drivers for project-based learning, allowing students to engage in the full cycle of product design and development under the guidance of instructors. At the same time, an intelligent management platform is developed to optimally orchestrate teaching resources such as course scheduling, laboratories, and faculty, ensuring the smooth implementation of project-based learning. In this way, the teaching process forms a cycle of "theoretical instruction → project practice → feedback and improvement": instructors impart multidisciplinary foundational knowledge in class, students apply what they have learned to industry-sponsored projects, and the results and feedback from practice are then used to refine course content and teaching strategies. This closed loop ensures that teaching and industrial practice iterate in sync, and students truly achieve learning by doing and doing by learning, bringing theory into practice.

## **3. Design and Functions of the Intelligent Scheduling System and Co-Creation Manufacturing Platform**

This section explains the implementation of the closed-loop teaching reform oriented by industry-education integration from a system perspective. As shown in Figure 1, the overall system architecture consists of two major parts: a university teaching resource intelligent management system (Modules 1-4) and a university-enterprise co-creation manufacturing platform (Modules 5-10), which are interconnected through data on teaching plans, resources, and evaluations to form a closed loop.



**Figure 1.** System architecture of the closed-loop reform for industry-education integration.

### 3.1. Design and Functions of the Intelligent Scheduling System

The intelligent scheduling system employs AI techniques to optimize course timetabling and the allocation of teaching resources in universities, providing a solid foundation for the closed-loop teaching process. The system mainly includes functional modules for course scheduling optimization, laboratory and equipment management, faculty intelligent matching, and teaching data analysis and feedback (corresponding to Modules 1-4 in Figure 1). The main functions of each module are outlined below.

**Module 1 (Course Scheduling Optimization):** This module uses optimization algorithms at its core to automatically generate conflict-free class timetables, taking into account constraints such as prerequisite relationships, faculty and student time preferences, classroom capacity, and equipment requirements. It employs reinforcement learning and genetic algorithms for iterative optimization, continuously improving the rationality and feasibility of scheduling results. The system supports rolling adjustments based on real-time data: if enrollment numbers change or instructors adjust their availability, the timetable is partially recomputed and updated automatically, achieving flexible schedule updates.

**Module 2 (Laboratory and Equipment Management):** This module offers an integrated service for laboratory reservation and scheduling. It uses IoT technology to collect real-time data on space utilization and presents it visually, enabling conflict alerts and identification of underutilized resources. For equipment management, Module 2 employs RFID and computer vision to track equipment check-outs and returns, and provides overdue alerts as well as maintenance scheduling (predictive maintenance based on usage frequency). This ensures the safety of instruments and improves the utilization efficiency of laboratory spaces and equipment.

**Module 3 (Faculty Intelligent Matching):** This module calculates the compatibility between instructors and courses using teacher profile data (including academic background, teaching experience, research areas, past teaching evaluations, etc.), and produces recommendations for course assignments while balancing faculty workload. It also takes into account individual teachers' interests and development plans to intelligently recommend suitable course or project opportunities. This approach meets instructional needs while supporting faculty growth, thereby enhancing the overall effectiveness of the teaching team.

**Module 4 (Teaching Data Analysis and Feedback):** This module aggregates diverse educational data - such as schedules, course enrollment, teaching evaluations, lab utilization rates, and student performance - and displays key metrics via a dashboard, with automatic alerts for anomalies. Using historical data mining, it identifies imbalances between supply and demand as well as teaching risks, providing recommendations for adding or adjusting courses, reallocating resources, and improving teaching methods. Moreover, Module 4 connects with data from the co-creation platform, incorporating feedback from project implementation into the teaching evaluation system to form a cross-domain data closed loop (see Section 3.2 for details). Through these capabilities, the intelligent scheduling system not only ensures smooth teaching operations but also provides data support for continuous improvement.

### 3.2. Design and Functions of the University-Enterprise Co-Creation Manufacturing Platform

The university-enterprise co-creation manufacturing platform is the core of the practical phase in the closed-loop teaching model. It provides a cloud-based collaboration and delivery workflow for projects jointly conducted by universities and enterprises. The platform encompasses modules for project announcement, team formation, task collaboration, AI-assisted creative design, prototype manufacturing integration, and outcome management and evaluation (corresponding to Modules 5-10 in Figure 1). The specific functions of each module are as follows:

**Module 5 (Project Announcement and Team Formation):** Enterprises post real-world project topics and deliverable requirements online, and faculty mentors and student teams are matched to these projects based on course objectives and required competencies. Using skill and interest profiles of participants, the platform recommends suitable projects and mentors, rapidly forming a collaborative team comprising an "industry mentor + faculty member + students," and clarifying the role and responsibilities of each member.

**Module 6 (Task Collaboration and Resource Sharing):** This module provides mechanisms for breaking down project tasks, tracking progress, and submitting results. It supports tracking milestones using Gantt charts or kanban boards to visualize the status of each task. The platform builds a resource repository that connects the university's educational resource database with the enterprise's knowledge base, enabling unified accumulation and reuse of materials, standards, and case studies, thereby providing knowledge support for project innovation.

**Module 7 (AI-Assisted Creative Design):** The platform integrates multimodal AI creative tools provided by enterprise partners to support a continuous design workflow from concept generation and scenario simulation to 3D modeling. Generative AI is used to rapidly produce a variety of sketch ideas or initial model drafts, while intelligent modeling and optimization algorithms convert creative concepts into manufacturable digital models. This process shortens the design iteration cycle and improves the quality of design solutions.

**Module 8 (Prototype Manufacturing Integration):** This module interfaces with enterprise cloud-based additive manufacturing services (e.g., 3D printing) as well as the university's on-campus equipment database, enabling users to submit fabrication/printing jobs online, visualize the queue in real time, and receive completion notifications. The platform simultaneously captures manufacturing data such as material consumption and processing time for each task, feeding it back to the project team to inform design refinements. It also links with Module 2's laboratory management to enable the sharing and complementing of fabrication capacity between on-campus and off-campus facilities.

**Module 9 (Communication and Mentorship):** This module integrates instant messaging, discussion forums, and video conferencing features to facilitate team communication and remote mentorship. It records key discussions and review comments for accountability. The platform provides a "Mentor Dashboard" that allows mentors to monitor project progress, offer ongoing guidance, and track issues, thereby improving the frequency and quality of communication in the university-enterprise team. Effective communication has been shown by relevant research to have a significant positive impact on innovation outcomes [8].

**Module 10 (Outcome Management and Evaluation):** This module uniformly archives all project process materials and final deliverables with version control and traceability, including design documents, source code, prototype records, presentation materials, etc [9]. The platform facilitates a multi-dimensional evaluation of project outcomes by industry mentors, faculty, and students, considering criteria such as innovation, practicality, aesthetics, and learning gains. It also collects feedback surveys on the team collaboration process. The evaluation results are transmitted back to Module 4

via an interface, providing data for teaching improvement in a closed-loop manner. In addition, the platform supports showcasing outstanding outcomes and incorporates incentive mechanisms to stimulate students' innovative motivation.

Through these functional modules, the co-creation manufacturing platform uses concrete projects as vehicles to realize efficient collaboration between universities and enterprises: students carry out a full "design-manufacture-evaluation" closed-loop practice driven by real-world problems, faculty integrate the cutting edge of industry into their teaching, and enterprises obtain innovative ideas and human resources. All parties benefit from this arrangement. Meanwhile, the process and outcome data accumulated on the platform flow back into the educational analysis module, providing data support for the continuous iteration of projects and ongoing improvement of courses. This ensures that industry-education integration evolves from one-off collaborations into a sustainable, cyclical development model.

### *3.3. System Operational Effects and Application Value*

From an operational perspective, the system effectively integrates the two chains of "course scheduling - resource allocation - faculty assignment - data analysis" and "project initiation - collaborative development - creative design - prototype manufacturing - outcome evaluation," forming an executable closed-loop process. The deployment of intelligent scheduling and resource management modules has reduced scheduling conflicts and resource mismatches, improving the accessibility and utilization of laboratories and equipment. Meanwhile, the co-creation platform embeds real enterprise problems into teaching via a standardized workflow, enabling students to complete rapid iterations from conceptual design to prototype realization within a single project cycle.

In pilot applications with industry projects, the platform-based collaboration made stages such as project initiation, team formation, task breakdown, process guidance, and outcome evaluation more transparent and traceable. The AI-assisted creative design and prototype manufacturing integration significantly shortened the transformation path from "idea → model → prototype," reducing communication costs and the burden of rework. At the same time, project evaluation results and process data flowed back into the teaching data analysis module, providing a basis for subsequent course planning, resource investment, and pedagogical improvements, and thereby enabling continuous optimization.

In terms of educational outcomes, the system helps establish a capability chain of multidisciplinary collaboration. Students undergo comprehensive training under real-world constraints-covering needs analysis, design presentation, digital modeling, manufacturing validation, and team collaboration. Faculty continuously update their course content and teaching methods, guided by data feedback and enterprise needs. Enterprises, by participating in the evaluation and capturing case assets, obtain reusable innovative results and talent assessment information. Thus, the system provides a replicable and scalable digital support framework for industry-education integration. Similar innovative educational practices have also been shown to significantly improve students' employability and engagement.

## **4. Conclusion**

This paper presents a new teaching reform model oriented by industry-education integration, addressing the needs of talent cultivation in a multidisciplinary context. By building an intelligent scheduling system and a university-enterprise co-creation manufacturing platform, the model deeply integrates classroom teaching with industrial practice to form a closed-loop educational process. The reform practice demonstrates that optimizing teaching resource allocation with intelligent scheduling can effectively improve operational efficiency and fairness in resource utilization. Introducing real industry projects enables students to "learn by doing" and "do while learning,"

significantly enhancing their practical innovation capabilities. The positive interaction between academia and industry also brings tangible innovative outcomes to enterprises, reflecting a "triple-win" collaborative effect for universities, students, and companies. This model aligns with national strategies to advance industry-education integration and the convergence of science and education, and it has positive implications for higher education in improving the quality of talent cultivation and the capability to serve industrial development [10]. Through the closed-loop feedback mechanism, the education chain and talent chain are organically connected with the industry chain and innovation chain, enabling continuous improvement. Although this study is still in an early implementation stage, its concept and framework are generalizable and can serve as a reference for other institutions and sectors to carry out industry-academia collaboration reforms. In the future, we will continue to refine the management mechanisms and policy support for collaborative innovation and further investigate the patterns and models of industry-education integration in interdisciplinary fields, in order to continuously iterate and enhance this reform approach. We believe that with the joint efforts of government, academia, and industry, the closed-loop talent cultivation model of industry-education integration will continuously inject momentum into the high-quality development of China's higher education.

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