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| RESEARCH ARTICLE

Research on the Deep Integration of CDIO and Maker Education to Promote the Cultivation of Innovative Talents in Emerging Engineering Disciplines

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| ABSTRACT
"First-class practical projects" constitute one of the four fundamental elements of the Undergraduate Education Teaching Reform Pilot Work Plan (Plan 101), aiming to cultivate future "revolutionary" and "disruptive" talents in emerging engineering disciplines. Both CDIO engineering education and maker education are committed to nurturing students' innovative and practical abilities, serving as robust pillars for the cultivation of talents in emerging engineering fields. Based on a review of relevant literature on CDIO engineering education and maker education from both domestic and international sources, this paper analyzes the differences between the two in terms of educational philosophy, curriculum system and content, teaching faculty, teaching resources, teaching methodologies, and evaluation methods. It proposes the concept of deeply integrating CDIO with maker education, outlining methods for such integration: constructing a curriculum system that merges CDIO with maker education, compiling textbooks for an engineering practice system that incorporates maker projects within the CDIO framework, establishing a makerspace through school-enterprise collaboration that integrates engineering practice with maker activities, building a practical teaching model that fuses CDIO with maker education, formulating a diversified evaluation scale that combines qualitative and quantitative assessments, and organizing competition activities that integrate CDIO with maker education. Furthermore, a comprehensive practical case study of the deep integration of CDIO and maker education is provided.

| KEYWORDS

Emerging Engineering; CDIO; Maker Education; Deep Integration; Innovative Model

| ARTICLE INFORMATION

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1. Introduction

Cultivating people with virtue and high-quality innovative talents is the talent cultivation goal and the theme of the times for higher education institutions. With the continuous advancements in technologies such as the Internet, Internet of Things, artificial intelligence, and intelligent manufacturing, there is a growing demand across industries for new engineering talents equipped with entrepreneurial awareness, digital thinking, and cross-disciplinary integration capabilities. In February 2017, the Ministry of Education actively promoted the development of new engineering disciplines, with the "Fudan Consensus," "Tianjin Initiative," and "Beijing Guidelines" forming the "trilogy" of new engineering development and opening up new paths for engineering education reform. In September 2018, the Ministry of Education's "Opinions on Accelerating the Development of New Engineering and Implementing the Excellence Engineer Education and Training Program 2.0" proposed that multi-entity collaborative industrial and future colleges should be established, and that more than 20% of engineering majors should undergo internationally recognized professional certification [1]. In May 2020, the Ministry of Education issued the "Guidelines for the Construction of Future Technology Colleges (Trial)," which emphasized the need to "focus on the demand for future revolutionary and disruptive technological talents," and to "break through conventions, constraints, and barriers, while strengthening reform, innovation, and leadership" in order to accelerate the cultivation of technological innovation talents with forward-thinking and cross-disciplinary capabilities [2].

In July 2024, the Department of Higher Education of the Ministry of Education issued the "Notice on Carrying out the Work of Setting Up Undergraduate Majors in Ordinary Colleges and Universities in 2024" (Jiaogao Sihan [2024] No. 7), proposing to support universities in establishing relevant majors in key fields such as integrated circuits, artificial intelligence, quantum technology, life health, energy, green and low-carbon, and to cultivate national strategic talents and talents in short supply with a clear purpose [3].

Meanwhile, the state attaches great importance to the educational and teaching reform of new engineering disciplines. In December 2021, the pilot work plan for undergraduate educational and teaching reform (referred to as the "101 Plan") was first launched in the field of computer science. The key tasks include promoting the construction of "four first-class" elements: first-class core courses, first-class core textbooks, first-class teaching teams, and first-class practical projects, using these foundational elements to drive systematic educational and teaching reforms and foster top-notch innovative talents. In April 2023, the Ministry of Education initiated the "101 Plan" series for basic disciplines in mathematics, physics, chemistry, and biological sciences, further advancing the development of new engineering, new medical sciences, new agricultural sciences, and new liberal arts, and leading the way in improving the quality and innovation of higher education [4]. A series of conferences, including the International Symposium on Engineering Education (Suzhou), the Annual Meeting of the Engineering Education Professional Committee of the China Association for Higher Education (Lanzhou), and the Curriculum System and Course Teaching Construction for New Standards in Engineering Education (Shenyang), were held in 2024 to discuss topics such as international exchange and cooperation in engineering education and innovative teaching modes for new engineering education, exploring the relevant theories and practices of engineering education in China from multiple dimensions.

The cultivation of innovative talents in new engineering disciplines is a systematic project, in which teaching modes play a pivotal role. Numerous scholars have conducted innovative research from perspectives such as CDIO engineering education and maker education, and attempted to integrate CDIO with maker education to implement cross-disciplinary innovative talent cultivation at various levels, including basic education, vocational education, and higher education.

2. Review of Research on the Deep Integration of CDIO and Maker Education

2.1 Domestic Research

CDIO stands for Conceive, Design, Implement, and Operate, jointly proposed by four higher education institutions including the Massachusetts Institute of Technology and the Royal Institute of Technology in Sweden, aiming to standardize the engineering education process and enhance students' interdisciplinary comprehensive practical abilities. Maker education, based on students' interests, adopts a project-based learning approach, utilizes digital tools, advocates creation, encourages sharing, and cultivates interdisciplinary problem-solving skills, team collaboration abilities, and innovation capabilities as a form of quality education.

CDIO engineering education and maker education share a high degree of congruence in educational goals, both committed to cultivating students' innovative and practical abilities, providing strong support for the cultivation of new engineering talents. As a result, numerous scholars have integrated separate research on CDIO or maker education. In 2017, scholars such as Zhu Yuping et al. [5] proposed integrating the educational concept of CDIO, which encompasses conceiving, designing, implementing, and operating, into maker education, thereby organically combining the "learning by doing" approach to solving unknown engineering design problems with the "DIY creation of unknowns" movement in maker culture. In 2018, scholar Zhang Decheng [6] proposed a hybrid innovation model that integrates the conceiving, designing, implementing, and operating processes of CDIO with maker education under the guidance of innovative ideas, aiming to effectively enhance the quality and level of "mass entrepreneurship and innovation" and improve the innovative capabilities and core competitiveness of engineering education professionals and the general public. In 2020, Ye Huamin[7] introduced a maker teaching mode that combines STEM+CDIO, utilizing the interdisciplinary connectivity and multidisciplinary integration characteristics of STEM education as teaching objectives, adopting the CDIO international engineering practice model as a teaching strategy, and using the maker ability structure as the content for teaching evaluation. Through specific teaching cases, the connotation and process of this teaching mode were deeply explained, providing new ideas and directions for the specific implementation of maker teaching. In the same year, scholar Dai Jianfa [8] proposed the "Q-CDIO-S" engineering education innovation model, which adds "Q-Question" (problem or demand) and "S-Share" (sharing) to the CDIO framework, and conducted practical exploration in secondary vocational maker education. Some scholars have also applied the integration of CDIO and maker education to practical teaching in college English courses and middle school maker courses, achieving promising research results.

2.2 International Research

CDIO engineering education not only inherits and develops the reform ideas of engineering education that have been prevalent in Europe and America for more than 20 years but also systematically proposes 12 actionable standards for capability cultivation, comprehensive implementation, and assessment. International literature indicates that research in this field is gradually becoming more specific, actionable, and measurable. Thi-Phuong Le [9] explored the perceptions of students at the National University of Ho Chi Minh City, Vietnam, regarding the assessment of learning outcomes based on the CDIO model, as well as how individual student characteristics and the university educational environment influence assessment results. David Wattiaux [10] investigated the promotion of STEM education through the CDIO approach in FabLabs manufacturing laboratories. Chunshu An et al. [11] experimentally tested the effectiveness of an innovative educational teaching mode under the CDIO concept in terms of students' learning perceptions and academic achievements.

In the field of maker education, there is a wealth of research findings abroad regarding makerspaces, the implementation of maker education, and related topics. Banks-Hunt et al. [12] emphasized the integration of makerspaces, student-centered learning, curricula, and teacher training into STEM education in middle schools. Charlwood [13] pointed out that maker education can provide an effective path for cultivating new engineering talents who are adapted to the needs of the AI era. Wang Z [14] explored the cultivation path of innovative abilities for scientific and technological talents in the context of big data. He proposed a cultivation path for innovative abilities based on the background of big data, utilizing methods such as maker education and practical projects. Some scholars have also explored the research and practice of the "job rotation interaction" innovative talent training model between schools and enterprises under the "maker platform" by establishing a maker education platform, they facilitate cooperation between schools and enterprises, enabling students to participate in job rotation internships and interactive exchanges in actual projects, thereby cultivating their innovation and practical abilities.

However, there is relatively little research on the deep integration of CDIO and maker education.

3. Comparison of CDIO Engineering Education and Maker Education

CDIO engineering education and maker education share similarities in emphasizing practical and innovative ability cultivation, advocating the educational philosophy of "learning by doing," highlighting teamwork and sharing, as well as integrating multidisciplinary knowledge and skills. These similarities indicate that both educational models have common goals and pursuits in cultivating students' comprehensive qualities and innovative abilities. However, there are also certain differences between them, which are manifested in the following aspects.

3.1 Educational Philosophy

CDIO engineering education embodies a systematic and holistic engineering philosophy, closely linked to industrial practice. It emphasizes the entire lifecycle of a product, from research and development to operation, as a carrier for students to learn engineering in an active, practical, and interconnected manner across courses. This approach focuses on cultivating systematic engineering abilities, requiring students to understand the complexity of engineering systems and the interrelationships between various stages.

In contrast, maker education follows an educational philosophy of openness, innovation, creativity, exploration, and experience. It starts with students' interests, emphasizing the generation and realization of creative ideas, and turning those ideas into reality. Maker education is more concerned with stimulating individual creativity, cultivating students' innovative thinking and practical abilities, and allowing them to explore topics of interest through practice. Unlike CDIO, it does not focus on the completeness of engineering systems but rather on fostering creativity and hands-on skills in a more flexible and personalized manner.

3.2 Curriculum System and Content

CDIO engineering education features a comprehensive and practice-based curriculum system. The courses are closely interconnected and centered around engineering projects. These projects encompass various stages, from the conception of system architecture, hardware and software design, to system implementation and debugging, requiring students to comprehensively apply their learned knowledge.

In contrast, maker education offers a flexible and diverse curriculum content. There is typically no fixed curriculum framework; instead, it guides students to autonomously learn relevant knowledge and skills based on the needs of their creative projects. Unlike CDIO, maker education does not adhere to a strict sequential order of disciplinary knowledge systems. It can cover knowledge from multiple fields, such as electronics, mechanics, programming, arts, and more, allowing for cross-disciplinary integration and exploration.

3.3 Teaching Staff

A first-rate teaching staff serves as the foundation for cultivating innovative talents in the new engineering disciplines and is a prerequisite for curriculum optimization and educational reform. CDIO engineering education requires teachers to possess a strong background in engineering disciplines, rich practical experience in real-world settings, and capabilities in international cooperation and exchange. They must also demonstrate strong systematic thinking, scientific thinking, and innovative thinking skills. Particularly, they need to have a systematic understanding of interdisciplinary knowledge. For instance, in a bridge construction project, teachers should be able to select appropriate building materials based on knowledge of materials mechanics, design the bridge structure using structural mechanics, while also considering practical construction techniques and processes in civil engineering, as well as the environmental impact on the bridge.

Maker education similarly emphasizes the integration and application of interdisciplinary knowledge, thus requiring teachers to have interdisciplinary integration capabilities. However, teachers in maker education are often not limited to full-time school teachers, nor are they necessarily guided by a single teacher. They can be a combination of teachers from multiple disciplines, including doctors, civil servants, or even front-line workers. Students, based on the needs of their maker projects, seek help and guidance from the required teachers. This approach focuses on cultivating students' openness, innovation abilities, and facilitating the transformation of creative ideas into real products.

3.4 Teaching Resources

CDIO engineering education emphasizes engineering practice, so its teaching resources encompass not only systematic engineering knowledge and skills but also engineering practice projects, engineering design cases, engineering software tools, and more. Due to the close collaboration between CDIO engineering education and enterprises, teaching resources also include actual engineering projects, technical standards, and industry norms from the industry. In today's highly developed online education environment, the country has leveraged the situation to construct a wealth of high-quality online and open teaching resources, such as national excellent courses and virtual simulation experiments. These resources enrich students' learning experiences, help them understand real engineering environments, master engineering design and implementation methods, and promote personalized learning.

Maker education, on the other hand, emphasizes innovative thinking and practical abilities. Therefore, its teaching resources primarily focus on innovative practice projects, creative toolkits, open-source hardware and software, and the like. Maker education encourages interdisciplinary learning and collaboration, so its teaching resources also encompass knowledge and skills from different disciplines, such as science, technology, art, mathematics, and more. Emphasizing the power of communities and networks, maker education's teaching resources also include makerspaces, online communities, open-source projects, and other platforms for exchange and cooperation. These resources provide students with opportunities to broaden their horizons, stimulate their interest in learning, and facilitate the sharing of successful experiences.

3.5 Teaching Methods

CDIO engineering education primarily adopts a project-driven approach. Teachers, based on the process and requirements of project-driven learning, set up engineering projects and develop plans through the CDIO model of conception, design, implementation, and operation. They guide students in activity exploration and promptly address students' questions through collaboration among teachers, students, and AI teachers. The teachers also conduct多元化evaluation of students' outcomes. In this process, teachers play the role of project mentors, guiding students through engineering projects. The teaching emphasizes teamwork and standardized engineering processes, allowing students to gradually master engineering methods and skills as they complete projects.

Maker education, on the other hand, places greater emphasis on heuristic and self-exploratory methods. Students determine their creative ideas based on their interests and hobbies, explore and attempt to turn these ideas into reality. Students are encouraged to practice hands-on and enhance their abilities through making and innovating. Teachers primarily serve to inspire students' creative inspiration and provide necessary tool and resource support, including physical resources and curriculum resources. When students encounter difficulties, teachers offer hints. Maker education emphasizes students' autonomous learning and personalized creation.

3.6 Evaluation Methods

In CDIO engineering education, evaluation is typically comprehensive, combining both process-oriented and outcome-oriented assessments. Students' performance in engineering projects is evaluated from multiple dimensions, including the quality of project documentation (such as requirements analysis reports, design specifications, etc.), team collaboration skills (whether the division of labor among team members is smooth, communication is effective, etc.), and the quality of project outcomes (whether the product meets expected functional and performance indicators). The evaluation process spans the entire lifecycle of the project, with corresponding evaluation indicators for each stage.

Maker education, on the other hand, places greater emphasis on the novelty of ideas and the degree of realization of works. For students' creative works, the primary consideration is whether the idea is unique and valuable, followed by whether the work successfully achieves its intended function. Compared to CDIO, the emphasis on process standardization and documentation requirements is less stringent. Instead, maker education focuses more on students' innovative thinking and hands-on abilities demonstrated during the idea generation and realization process.

A comparison between CDIO engineering education and maker education is shown in Table 1.

Table 1: Comparison between CDIO Engineering Education and Maker Education

Comparison Type		CDIO Engineering Education	Maker Education
Similarities		Emphasize the cultivation of practical and innovative abilities.	
		Advocate the educational philosophy of "learning by doing".	
		Emphasize teamwork and sharing.	
		Integrate multidisciplinary knowledge and skills.	
Difference	Educational Philosophy	The systematic approach of large-scale engineering, closely linked to industrial practice, emphasizes the entire lifecycle of a product from research and development to operation.	Free and open, innovative and creative, inquiry-based and experiential.
	Curriculum System and Content	A complete and systematic system of engineering theory and practice.	No fixed curriculum framework, set up as needed.
	Teaching Staff	Interdisciplinary teachers and engineers.	Teachers from various disciplines, industry technicians, civil servants, and other members of society.
	Teaching Resources	Course system knowledge and skills, actual engineering projects, technical standards and industry norms, virtual simulations, etc.	Innovative practice projects, creative toolkits, open-source hardware and software, knowledge and skills from different disciplines, online communities, makerspaces.
	Teaching Method	Project-driven method, engineering and virtual simulation practice method, flipped classroom teaching method.	Heuristic and independent inquiry-based methods.
	Educational Evaluation	Precise evaluation of the CDIO lifecycle	Innovation novelty, product uniqueness, and value.

4. Deep Integration of CDIO Engineering Education and Maker Education

Since its establishment, the CDIO model has been adopted by nearly 150 renowned universities worldwide, providing a foundation for the systematic development of engineering education and serving as a model for the reform of compound innovative talent and application-oriented talent cultivation modes. However, the CDIO model overly emphasizes the needs of the industry, making it unsuitable for all majors, and the "design-to-implementation" experience is difficult to achieve. Additionally, it may neglect the essential attributes of education and the comprehensive development of students, potentially leading to a misalignment of educational functions, a shift in educational subjects, excessively high teaching and learning requirements, and cumbersome evaluation processes that may burden teachers and students.

Maker education, essentially "learning through creation," fosters interdisciplinary theoretical learning and practical innovation by transforming students' ideas into tangible products through the "making" process, based on their individual interests and hobbies. It supports exploration and innovation by introducing new tools for modern design, such as 3D printing, and new methods for creative thinking. Nonetheless, maker education faces challenges such as a lack of systematic interdisciplinary theoretical and skill learning, a shortage of high-quality maker-type teachers and course resources, inconsistent standards for maker space construction, low-quality and disordered student innovation, uneven regional implementation of maker education, and limited student coverage.

By deeply integrating CDIO engineering education with maker education, we can overcome their respective limitations and achieve systematic, standardized, and personalized cultivation of innovative talents.

4.1 Constructing a Curriculum System that Integrates CDIO with Maker Education

In the design of new engineering education programs, apart from joint development by schools and enterprises, it is essential to leverage the capabilities of artificial intelligence and big data to construct a professional knowledge graph. This graph organizes and displays entities such as knowledge points, concepts, theories, and their relationships within the discipline, facilitating curriculum designers to grasp the discipline's context and form a systematic knowledge system. Simultaneously, based on the knowledge graph, the connections and dependencies between skill points are clarified, and the optimal path to achieve target skill points is established, providing a standardized reference for talent skill assessment. The knowledge graph can quickly absorb new knowledge and eliminate outdated information, aiding in the identification of key information related to technology, markets, and user needs for projects, and enabling timely updates. This enhances the precision of project mining, provides innovative ideas for maker projects, and potentially uncovers hidden innovation opportunities.

By constructing the curriculum architecture based on the knowledge graph, the four stages of CDIO are integrated with the core principles of maker education, forming a comprehensive curriculum system. For instance, in the early stages of education, emphasis is placed on cultivating students' innovative thinking and maker awareness; in the advanced stages, the CDIO project-based teaching method is utilized to guide students in applying maker concepts to solve practical problems.

4.2 Reconstructing the Textbook System for Engineering Practice and Designing Maker Projects within the CDIO Framework

One of the key tasks of the "101 Plan" is to develop first-class core textbooks that "reflect the international academic frontier and possess Chinese characteristics," emphasizing the integration of theory and practice, highlighting case analysis and problem-orientation, and embodying advanced nature, innovation, and challenge. In the compilation of textbooks, knowledge graph technology is utilized to present knowledge points, skill points, and their interrelationships in a graphical structure, optimizing the layout of knowledge and skills. Teachers can refine practical projects based on the knowledge and skill pathways in the knowledge graph and design maker projects within the CDIO framework. This approach maintains the rigor, integrity, and systematic nature of the CDIO process while stimulating students' innovation and inquiry drive through maker projects.

4.3 Jointly Establishing an Integrated Space for Engineering Practice and Maker Activities by Universities and Enterprises

The cultivation of practical abilities for new engineering talents requires the support of a real practice environment. Many universities collaborate with enterprises to jointly construct engineering practice bases. Based on the enterprises' demands for talent capabilities, universities develop targeted practice curriculum systems, including internships, practical training, and project cooperation, to ensure that students can fully grasp practical skills. At the same time, elements of actual production, management, and technology from enterprises are integrated into the teaching content, enabling students to master professional knowledge through practice. Additionally, many practice base constructions also consider the integration of maker spaces, including virtual simulation, augmented reality, and other virtual practices, to ensure experimental safety and effectiveness while improving the utilization rate of practice facilities.

4.4 Constructing a Practical Teaching Model Integrating CDIO and Maker Education

The CDIO process of conception, design, implementation, and operation in engineering practice follows a relatively fixed flow, ensuring a certain degree of scientific rigor and standardization in practice. Although maker education's practical activities have a certain innovative goal, the process is relatively arbitrary, which may lead to detours or even failures due to a lack of systematicity and scientific rigor. Deeply integrating maker education with CDIO can effectively address the issues of CDIO's rigidity in innovation and maker education's lack of scientific rigor and disorder in innovation.

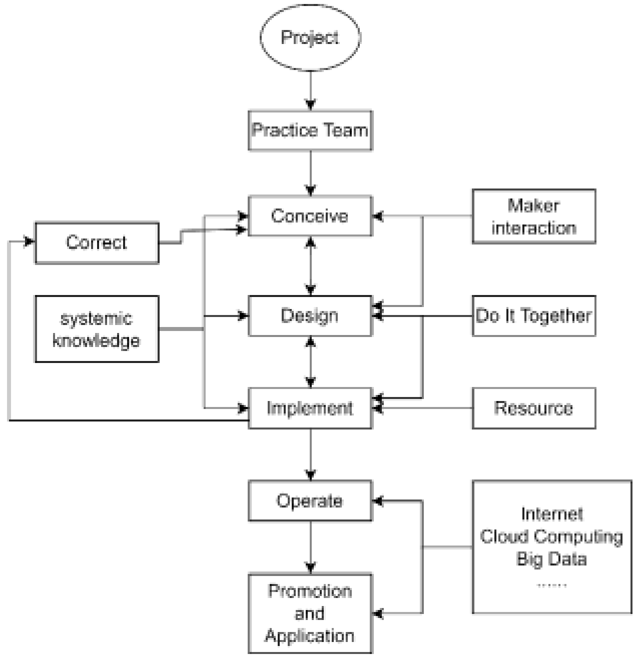

Figure 4: Maker-CDIO Education Model

Based on engineering practice projects, a practice team is formed, with team members grouped heterogeneously to complement each other in knowledge, abilities, and thinking modes. During the conception phase of the engineering project, team members interact like makers through brainstorming, discussions, and exchanges, forming ideas based on the problem's goals and requirements, and establishing system implementation modeling. They apply systemic knowledge to conduct interdisciplinary and comprehensive design. In the integrated practice space, they verify design ideas and develop systems or products through hands-on practice. They revise any issues in the design and conception to strive for functional perfection and standardization of the system or product. Through the internet and market research, they solicit opinions from users, conduct trial experiences, and utilize cloud computing and big data to optimize and improve the maker system or product. With the help of the internet, they promote and apply the innovation on a large scale, enabling the scaled production of the innovative system or product and achieving the product transformation of innovative knowledge.

4.5 Constructing a Diversified Evaluation Rubric Combining Qualitative and Quantitative Assessments

In response to the precise yet inflexible evaluation of CDIO in the engineering practice lifecycle, and the subjective evaluation of maker education that focuses on creativity and product uniqueness but lacks precision, a diversified evaluation rubric should be designed for the deeply integrated teaching of CDIO and maker education. This rubric should consider both the achievement data of CDIO knowledge and skills, as well as the process records of participation, contribution, and innovative performance. It should not only focus on the technical implementation and creativity of the work, but also value the design ideas, implementation processes, and team collaboration behind the work. By achieving an organic combination of process evaluation and summative evaluation, as well as qualitative and quantitative assessments, and leveraging the data collection and analysis functions of student learning behavior in a smart environment, a precise portrait of students' innovative practices can be created.

4.6 Organizing Competition Activities Integrating CDIO and Maker Education

Combining the characteristics of CDIO and maker education, various maker competition activities can be organized. The competitions revolve around specific themes or social issues, requiring students to participate in teams and create projects throughout the entire process from conception, design, implementation to operation. High-level competitions such as the "Challenge Cup" National College Students' Extracurricular Academic and Technological Works Competition and the China College Students' Computer Design Contest, which emphasize interdisciplinary innovative design and technological application, can stimulate students' enthusiasm for innovation and practical motivation, while promoting the deep integration of CDIO and maker education.

5. Practical Case of Deep Integration of CDIO and Maker Education

The following is an example of the practical project "Intelligent Traffic Data Analysis and Optimization System" in the course "Data Mining Technology and Applications" to illustrate the deep integration of CDIO engineering education and maker education.

Course: Data Mining Technology and Applications

Project: Intelligent Traffic Data Analysis and Optimization System

Objective: To develop a big data-based intelligent transportation system that analyzes traffic flow data to optimize traffic signal control, reduce traffic congestion, and improve road safety.

The integrated design process of CDIO engineering education and maker education is shown in Table 2.

Table 2: Deep Integration of CDIO Engineering Education and Maker Education

CDIO Engineering Education	Maker Education
Conceive (1) Needs Analysis: Collaborate with traffic management departments to collect data on traffic congestion and the current status of signal light control. ● Including: ○ Data Sources (where the data comes from, types of data) ○ Functional Requirements: traffic signal optimization, real-time traffic monitoring, traffic status prediction, congestion warning and dispersion, etc. ○ User Groups (who will use the system) (2) Conceptual Design: Conceive an intelligent transportation system based on big data, encompassing all stages of data collection, processing, analysis, and application. (3) Technology Selection: ● Utilize distributed computing frameworks such as Hadoop to process large-scale datasets, including data integration, cleaning, storage, etc. ● Employ machine learning frameworks like scikit-learn, TensorFlow, or PyTorch to build predictive models, such as traffic flow prediction models, congestion recognition models, etc.	① Establish an innovation team; ② Determine the developable products, functions and market positioning through research and brainstorming.
Design (1) System Architecture Design: Design the technical architecture of the system, including the data acquisition layer, storage layer, computing layer, and application layer. (2) Algorithm Design: Design algorithms for traffic flow prediction and signal light optimization. Utilize machine learning frameworks to build predictive models, such as traffic flow prediction models and congestion recognition models. (3) User Interface Design: Design a user-friendly interface that allows traffic management personnel to easily monitor and adjust traffic signals.	① Learn interdisciplinary knowledge and skills related to product development; ② Master the key technologies and implementation methods of product development.
Implement (1) Data Collection: Collect real-time traffic data using sensors and cameras. (2) Data Processing: Clean, transform, and store the collected data using big data technologies. (3) Algorithm Implementation: Write code to implement the designed algorithms. (4) System Integration: Integrate various modules into a complete system.	The realization of product functions, such as intelligent traffic lights, smart maps, autonomous driving, real-time digital twins of cities, and smart parking.
Operate (1) System Testing: Test the system's performance and effectiveness in a real-world traffic environment. (2) Performance Optimization: Fine-tune the system based on test results. (3) User Training: Provide training to traffic management personnel on how to use the system. (4) System Deployment: Deploy the system at selected traffic intersections.	① Debug and optimize different products and functions; ② Product promotion.

Through comprehensive practical projects, students not only acquire professional knowledge and skills but also translate that knowledge into tangible products. These practical and innovative products can enhance the intelligence of traffic management, bringing revolutionary changes to urban transportation and thereby promoting sustainable urban development.

6. Conclusion

The deep integration of CDIO engineering education and maker education has become an important approach to cultivating future engineers and innovators. This innovative and integrated educational model, from the teaching perspective, facilitates the timely conversion of course knowledge and skills into innovative products in terms of course objectives. In terms of the construction of practice facilities, the establishment of a school-enterprise integrated engineering practice maker space provides a one-stop environment for interdisciplinary knowledge and skill learning. It also promotes the development of faculty teams, core textbooks, and other aspects. From the student perspective, students master scientific thinking methods, systematic knowledge systems, and standardized engineering practice abilities. They enhance their autonomous learning capabilities in interdisciplinary knowledge and skills through product development, laying a solid foundation for their lifelong learning and career development.

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Reference

[1] Ministry of Education's "Opinions on Accelerating the Development of Emerging Engineering Disciplines and Implementing the Excellent Engineer Education and Training Plan 2.0" [EB/OL]. https://www.gov.cn/zhengce/zhengceku/2018-12/31/content_5443530.htm
[2] Ministry of Education's "Guidelines for the Construction of Future Technology Institutes (Trial)" [EB/OL]. https://www.gov.cn/zhengce/zhengceku/2020-05/24/content_5514379.htm
[3] Department of Higher Education, Ministry of Education's "Notice on Carrying Out the Work of Setting Up Undergraduate Majors in Ordinary Higher Education Institutions in 2024" (Jiao Gao Si Han [2024] No. 7) [EB/OL]. http://www.moe.gov.cn/s78/A08/tongzhi/202407/t20240723_1142423.html
[4] Project 101 [EB/OL]. https://baike.baidu.com/item/101%E8%AE%A1%E5%88%92/63307630?fr=ge_ala
[5] Zhu Yuping, Zhang Xuejun. Research and Practice of Maker Education Based on the CDIO Concept [J]. Education Modernization, 2017, 4(36): 119-121+136. DOI:10.16541/j.cnki.2095-8420.2017.36.046.
[6] Zhang Decheng. Research on the Integration of Maker Education and CDIO [J]. China Education Informatization, 2018, (06): 6-9.
[7] Ye Huamin. Maker Teaching Mode Based on STEM+CDIO [J]. Educational Information Technology, 2020, (Z2): 23-26.
[8] Dai Jianfa. Innovation and Practical Exploration of the CDIO Engineering Education Model in Secondary Vocational Maker Education [J]. China Education Informatization, 2020, (12): 31-34.
[9] Thi-Phuong Le, Minh-Quang Duong, The Assessment of Student Learning Outcomes in Accordance with CDIO Model at the Vietnam National University Ho Chi Minh City. European Journal of Contemporary Education. 2021. 10(3)：653-663.
[10]Wattiaux D, Leroy C, Olivier B, et al. The CDIO approach in a FabLab activity for engineering education promotion[J]. 2021.
[11] Chunshu An1 , Jing Han1 ,等A Design Study to Enhance Students' Perceptions of Learning as well as Academic Achievement Based on Creative Education and CDIO Engineering Education Models. ResearchTrenz Press.2023（3）.DOI: 10.47750/RAA/11.3.14
[12] Banks Hunt J M, Adms S, Ganter S, et al. K-12-STEM Education: Bringing the engineering maker space, student centered learning, curriculum, and teacher training to middle schools[c]//Frontiers in Education Conference(FIE),2016 IEEE.IEEE,2016:1-5.
[13] Charlwood, A., & Guenole, N. (2022). Can HR adapt to the paradoxes of artificial intelligence. Human Resource Management Journal, 20, 545–566.
[14]Wang Zhiqiang. Cultivating Future Smart Makers: The Conceptual Logic and Operational Mechanism of Makerspaces in Universities [M]. Social Sciences Academic Press, 2022.