Engineering Education Reformation under the Perspective from CDIO to AI

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Abstract. In the face of profound changes in industrial scenarios during the digital and intelligent era, engineering education needs to break through the bottleneck of traditional paradigms and build a new system adapted to the development of intelligent technologies. This paper takes the CDIO engineering education model as a starting point to systematically review the evolution and practical achievements of CDIO in China. In the current era of deep penetration of AI technology, the traditional CDIO model has exposed deficiencies in capability cultivation. To keep pace with the times, engineering education must emphasise the integration of teaching and AI. By empowering the entire teaching process with AI, the transformation of engineering education can be achieved.

Keywords: CDIO, Education 4.0, AI, Engineering Education.

1 Introduction

Technological waves of industrial revolutions have always served as the primary engine driving reform in engineering education. The China Engineering Education Quality Report[1], based on enterprise surveys, acknowledged that graduates possessed solid foundational abilities, like professional knowledge and tool usage, but rated them low on cutting-edge knowledge, innovation, and the capacity to analyse and solve authentic engineering problems, highlighting a critical deficit in practical engineering competence.

It was against this backdrop that the CDIO (Conceive, Design, Implement, Operate) was initially introduced in 2005[2]. By making the project the organising principle of learning, CDIO dismantled the wall between theoretical study and engineering practice, precisely matching Industry 3.0's demand for "practice-oriented, systems-minded" engineers. Over the following two decades, CDIO became deeply intertwined with China's "Excellent Engineer Education & Training Plan"[3] and the "Emerging Engineering Disciplines" campaign, steadily raising the job-fit rate of engineering graduates and supplying the key human capital for the country's transition from a manufacturing giant to a manufacturing powerhouse.

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Yet the past few years have seen the world accelerate into the Industry 4.0 era[4], which is an age of intelligence. AI fluency is no longer optional across design-and-make roles, but also the future [4-6]. How to craft an engineering education that both meets the technological imperatives of Industry 4.0 and harnesses the transformative power of AI has become the defining question for engineering education.[7]

2 CDIO

2.1 History of CDIO

The CDIO concept was jointly created in 2000 by the Massachusetts Institute of Technology (MIT), the Royal Institute of Technology (KTH), Chalmers University of Technology, and Linköping University[8]. These institutions subsequently founded the international CDIO Initiative, which now counts more than 150 universities across five continents and over 30 countries. The 18th CDIO International Conference was hosted by Reykjavik University, Iceland, in June 2022 under the theme “Thriving-Preparing for the Future”.

The CDIO model was transplanted into China in 2005 by Shantou University. In 2016, the China CDIO Engineering Education Alliance (Alliance of CDIO) was established in Shantou, Guangdong Province; its membership now approaches 200 universities and enterprises [9].

2.2 CDIO Model

The CDIO model is articulated through one syllabus and twelve standards[10][11]. As shown in Table 1, the CDIO standards, including Standards 1, 4, 5, 6, 7 and 9, demonstrate the program's strong emphasis on practical application. These standards set high expectations for the engineering practice capabilities of teachers, students, and teaching venues.

Table 1. CDIO Standards 3.0.

No.	Note	Standards
S1	Standard 1	The Context
S2	Standard 2	Learning Outcomes
S3	Standard 3	Integrated Curriculum
S4	Standard 4	Introduction to Engineering
S5	Standard 5	Design-Implement Experiences
S6	Standard 6	Engineering Learning Workspaces
S7	Standard 7	Integrated Learning Experiences
S8	Standard 8	Active Learning
S9	Standard 9	Enhancement of Faculty Competence
S10	Standard 10	Enhancement of Faculty Teaching Competence
S11	Standard 11	Learning Assessment
S12	Standard 12	Program Evaluation

The conventional paradigm in which classroom lectures and laboratory exercises operate as largely independent silos can no longer satisfy the pedagogical demands posed by CDIO. Guided by the CDIO syllabus and standards, the curriculum should be reverse-engineered from “intended learning outcomes” [10].

2.3 Teaching Progresses

Curriculum design must break free from the lock-step of the textbook; it has to be learner-centred and purpose-driven. Instruction should migrate from “textbook-based teaching” to “standards-based teaching.” Anchored in the CDIO syllabus and its twelve standards, content is reverse-engineered from explicitly stated intended learning outcomes [12]. Practically, this implies a shift from topic-centred sequences to project-centred modules, mapping the inter-relationships of concepts and re-sequencing material to match authentic engineering contexts and project demands. Every learning element must specify the knowledge students must master and the competencies they must display, so that both teacher and learner are clear about what can and must be accomplished at each stage. The entire process is shown in Table 2. The Matching Matrix is shown in Table 3.

Table 2. CDIO Teaching Progress.

No.	Progresses of teacher	Progresses of student
P1	Problem Introduction	↓
P2	↓	Thinking & Discussion (C)
P3	Explanation & Demonstration	↓
P4	Guidance	Analysis & Design (D)
P5	Problem Correction	↓
P6	Instruction	Practice & Implementation (I)
P7	Comment	Self-assessment & Peer-assessment
P8	↓	Improvement & Operation (O)
P9	Evaluation & Summary	Summary

Table 3. Matching Matrix of Teaching Process and Standards.

	P1	P2	P3	P4	P5	P6	P7	P8	P9
S1	√	√	√	√	√				
S2				√		√			√
S3		√		√		√		√	
S4	√	√	√						
S5				√		√		√	
S6						√		√	
S7			√		√		√		
S8		√		√		√		√	
S9				√	√	√	√		
S10	√		√		√		√		√
S11							√		√
S12									√

3 Engineering Education Reformation

3.1 From Education 3.0 to 4.0

Education 1.0 is classroom learning. Education 2.0 is community learning and project-based learning. Education 3.0 is socialised learning[12]. At the dawn of the twenty-first century, the world entered the Industry 3.0 era centred on automation and informatisation. Intelligent upgrading of production lines and the widespread adoption of numerical-control technologies created a new profile for engineering talent. WEF released the first initiative of Education 4.0 in 2020. The WEF Education 4.0 Framework contains 8 key shifts. In the AI era, Innovation and creativity skills, Personalized and self-paced learning, Lifelong and student-driven learning require AI-powered education.

3.2 From CDIO to AI

Artificial intelligence(AI), big data, and digital-twin technologies are rewriting the underlying logic of industrial production. Production lines evolve from “automated” to “autonomous,” engineering problems shift from “single-technology fixes” to “complex-system orchestration,” and employer demand leaps from “operation-execution” profiles to “innovation-architect” ones.

From the perspective of Education 4.0, to better adapt to Industry 4.0, Engineering Education should embrace AI technology. Autodesk’s 2025 AI Jobs Report [5] underscores that AI fluency is no longer optional across design-and-make roles; U.S. job postings mentioning AI have surged 56.1% in 2025 (through April), building on explosive growth of 114.8% in 2023 and 120.6% in 2024, while human-centred skills are simultaneously in rising demand.

The deep penetration of AI into industry poses a triple challenge to education: reconstructing graduate outcomes, reinventing pedagogical models, and upgrading assessment systems. As Ye Min of Zhejiang University observes, engineering education must anticipate the future and cultivate talent suited to the new era before the need becomes urgent[6].

The integration of AI into engineering education is not merely desirable—it is imperative. At the national level, core competitiveness in the data-intelligence era hinges on a strategic reserve of AI-savvy engineers; Academician Zhu Gaofeng stresses that engineering education must undertake forward-looking research to keep pace with industrial demand. At the individual level, AI literacy has become a non-negotiable competency: Joseph Press’s 2035 engineer profile assumes AR headsets and AI copilots as standard equipment.

Feasibility is equally evident. The technological groundwork is maturing—intelligent learning platforms and virtual simulation systems are already operational on multiple campuses, while the CDIO Consortium’s Adaptive Convergence and Creativity through Integrated Innovation (ACCII) model supplies a coherent theoretical scaffold. Policy tailwinds are favourable: the 2023 China Engineering Education Blue Book charts a clear course for AI integration, and the Emerging Engineering Disciplines initiative provides institutional backing. Resource constraints are dissolving through refined university–industry collaboration mechanisms that open corporate AI assets to universities. [13]

3.3 Implementation

Future engineering education will converge on transformative trajectories: (1) Graduate profile from "skilled practitioner" to "intelligent-system architect." (2) Pedagogical model is to a "CDIO+AI" fusion paradigm. (3) Assessment regime is to a "competence-based+AI-augmented" ecosystem. (4) Smart analytics will provide fine-grained evidence of AI literacy and innovation capacity, replacing coarse proxy metrics with precision measurement. (5) Curriculum Re-engineering. Guided by the twin principles of "fortified fundamentals & AI infusion," the CDIO scaffold is extended with an AI-enablement layer that permeates every phase. (6) To strengthen faculty development, the institution has implemented a "Dual Competency Enhancement" initiative. This involves two key measures: recruiting enterprise AI experts through a school-enterprise mutual recruitment mechanism, and establishing an AI competency training system for faculty members, modelled after the CDIO Alliance's framework to enhance their AI teaching capabilities. Ultimately, this approach aims to cultivate students' AI proficiency and engineering literacy through the teaching process.

4 Conclusions

Characterised by strong operability, the CDIO framework has ignited a wave of reform across Chinese engineering programmes, exerting a radiating influence. It has charted a clear course for cultivating Chinese engineers aligned with international standards and for remedying long-standing weaknesses in domestic engineering education.

The reform of future engineering education should be based on the logic of inheritance and innovation, with the practice orientation of CDIO and the concept of the whole cycle as the foundation, injecting the empowering value of AI technology. Through systematic measures such as curriculum restructuring, platform upgrading, faculty development, evaluation innovation, and institutional safeguards, we aim to cultivate interdisciplinary talents with engineering literacy, intelligent capabilities, and ethical awareness. As advocated in the China Engineering Education Blue Book (2023), this transformation is not only the key to engineering education transitioning from running side by side to taking the lead, but also the core path to contribute Chinese perspectives to global engineering education.

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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