Article

Research on the Construction of Transportation Vehicle Design Curriculum System and Teaching Innovation Based on CDIO Educational Concept

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Abstract: ***Background:*** As the automotive industry advances towards intelligence, electrification and low-carbon solutions, transportation vehicle design education is also undergoing a transformation, gradually transitioning from basic styling training to developing systematic and interdisciplinary skills. The Conceive-Design-Implement-Operate (CDIO) educational concept provides a theoretical foundation for integrating engineering and design education. ***Purpose:*** This study aims to develop a transportation vehicle design curriculum system guided by CDIO to effectively combine design thinking with engineering logic, and enhance students' systematic thinking , practical skills, and the ability to adapt to industrial demands. ***Methods:*** The research adopts a comprehensive framework that follow the sequence of "conception - design - implementation – operation." It establish a project-based teaching loop that includes "demand insight - concept creation - digital model - solution iteration - verification and evaluation." In actual teaching, methods such as design thinking, digital modeling and virtual reality have been introduced into the classroom and hands-on activities. Additionally, through collaboration between schools and enterprises, along with dual-mentor system, the course content is closely aligned with industry demands. ***Results:*** After the implementation of the course, students' comprehensive abilities from concept generation to system operation have significantly improved, and their skill to balance artistic intuition and engineering constraints has been further enhanced, providing a reference for designing and optimizing future courses. ***Conclusion:*** The CDIO framework effectively integrate project-based learning, interdisciplinary content and industrial practice, providing a feasible approach for the transformation of design education from a focus on "academization" to "industrialization."

Keywords: CDIO; Transportation vehicle design; Project-based curriculum construction; Industry-University Collaboration; Interdisciplinary competence training

1. Introduction

1.1 Research Background

The Conceive-Design-Implement-Operate (CDIO) educational framework has been widely promoted in the global higher education system. It is recognized as an important path to promote innovation in engineering education. Compared with the traditional course-oriented model, CDIO emphasizes project-based learning and real-world experience. Its core objective is to help students develop comprehensive abilities from conceptualization to system operation. Since its introduction in Chinese universities, the CDIO framework has been continuously integrated and adjusted to meet cross-disciplinary teaching needs, including art and transportation design. During this transformation process, local educators have been constantly striving to strike a balance between "engineering logic" and "design innovation", ensuring that teaching not only preserves the systematic structure of CDIO but also maintains the inherent openness and humanistic orientation of the design discipline. The reform of the transportation design curriculum is highly consistent with this approach, emphasizing the dynamic relationship between teaching content and industrial demands. It also focuses on the comprehensive improvement of students' innovative, practical, and systematic thinking abilities (Ding & Wang, 2024).

Nowadays, the automotive industry is shifting towards intelligence, electrification, and low-carbon solutions, and transportation design education is also facing a new paradigm shift. Many universities are introducing concepts such as people-oriented travel experiences and intelligent interaction design through dual-degree programs, international workshops, and enterprise-collaborative curriculum systems. Meanwhile, the application of technologies such as virtual reality (VR), augmented reality (AR), and Digital Twins enables students to understand and test complex systems in an immersive environment. These changes not only reshape the knowledge structure of transportation design teaching but also prompt teachers to reconsider the "process-experience-reflection" cycle of design education (Fu & Wang, 2023). Over time, China's automotive design education has gradually formed a system structure of "historical inheritance, interdisciplinary integration, industry-education collaboration, and international partnerships". Future research and teaching reforms should further explore how to build an innovative, localized model for smart mobility and the coexistence of humans and vehicles.

1.2 Research Purpose

This research focuses on the connection between transportation vehicle design discipline and industrial development. Based on the CDIO educational concept, a project-oriented teaching system has been established. It covers five stages: "demand insight - concept of conception - digital model - solution iteration - verification and evaluation". This system is designed to enable students to gain hands-on experience throughout the entire process, from problem analysis to system implementation in a simulated industrial environment. The product, process, and system life cycle principles proposed by CDIO provide a theoretical basis for course design and serve as an overall framework for Project-Based Learning (PBL), enhancing students' practical abilities, systems thinking, and problem-solving skills.

In terms of specific teaching arrangements, project-based and situational tasks serve as the core components of the curriculum. These elements are integrated with design thinking, user research, ergonomics, modeling language, and digital modeling content to form an interdisciplinary curriculum system. Project-based and problem-oriented courses have also been proven in practice to enhance students' autonomous learning and innovation, providing a feasible operational model for engineering education. The research further emphasizes cooperation between schools and enterprises, as well as the introduction of real-world topics to establish a capability cultivation path of "theory - practice – innovation". Existing studies have shown that close cooperation between universities and enterprises can significantly enhance students' vocational abilities and align course content with industry needs. By incorporating enterprise demands, engineering standards, and real-world engineering parameters into the course design, the industrial relevance of the course and the impact of technology transfer can be enhanced.

1.3 Research Significance

Transportation design education in Chinese universities began in response to the evolving demands of the automotive industry and the expanding market. Since the end of the 20th century, with the reforms, opening up, and the gradual improvement of the industrial chain system, Chinese universities have begun to explore transportation vehicle design within the framework of industrial design disciplines. They have aimed to establish a comprehensive talent cultivation model integrating "design - engineering - industry".

Entering the 21st century, universities have generally established a curriculum system centered on the national innovation-driven strategy and advanced manufacturing strategy, with "humanistic understanding - engineering literacy - innovative practice" as the central theme, and set up key courses such as "Hand Drawing and Modeling", "Ergonomics", "Automotive Engineering and Design", "Digital Modeling", and "Color, Material and Process (CMF) Design".

On a practical level, collaboration between universities and enterprises have been introduced to enhance the connection between academic content and industrial demands. This enables students to engage in theoretical learning while simultaneously applying their knowledge in practical settings. In terms of course organization, teaching typically follows a multi-round, short-cycle iterative design approach. Each round generates evaluable outcomes, and adjustments are made based on feedback. This approach ensures the flexibility and adaptability of the teaching process (Liu, 2024) while enhancing students' problem-solving and innovation skills in real industrial environments.

2. Literature Review

With the continuous advancement of outcome-oriented education and the in-depth implementation of the engineering education accreditation system in Chinese universities, the CDIO education concept has been gradually introduced into the design discipline. In the field of transportation design, this concept not only implies an update in teaching paradigms but also indicates a significant transformation in interdisciplinary methodologies. The CDIO framework, characterized by systematic engineering thinking, ability-oriented learning paths, and comprehensive project-based practice, is regarded as a vital link between "teaching process" and "learning outcomes" (Wang & Hong, 2009). As a result, education in transportation vehicle design is gradually shifting from a training model centered on skills and work presentation to a teaching system focused on developing systematic abilities and designing innovative mechanisms.

The existing research on this topic can be categorized into three stages: 1) the initial introduction of concepts; 2) the curriculum innovation of teaching experiments; 3) the systematic professional development (Zhao & Zhang, 2020). As the research progresses, the practice of CDIO in transportation vehicle design education has given rise to three main research lines: theoretical frameworks, teaching experiments, and institutional innovation. Based on this, scholars usually summarize the relevant research into three dimensions: 1) The theoretical framework of CDIO and its localization translation; 2) Innovation in curriculum and teaching models based on CDIO; 3) Construction of Professional Training System and industry-university Collaboration Mechanism under CDIO Orientation ,as shown in Figure 1.

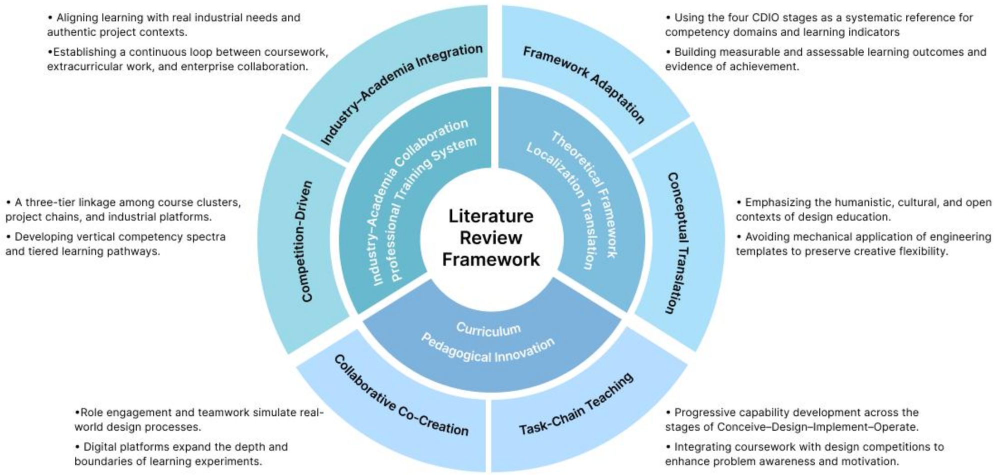

Figure 1: Framework of the literature review

2.1 The Theoretical Framework and Localization Translation of the CDIO Concept

The core discussion at the theoretical level centers on aligning the engineering logic of CDIO with the creative approach of design education. Researchers generally believe that the four-stage structure of CDIO - conception, design, implementation, and operation - provides a systematic reference for competency-based teaching reform (Li, 2021; Zhang et al., 2024). However, design education is not merely about developing engineering skills; it also involves artistic and cultural qualities. This tension has led the academic community to propose two main approaches to localization.

One approach is called the “framework adaptation,” which focuses on establishing a quantifiable, evaluable design education capability model based on the CDIO engineering standards. This method emphasizes systematic design and clarifies the course objectives through outcome mapping and a capability matrix (Gu et al., 2017). Another approach is “concept translation,” which does not pursue framework consistency but emphasizes the reinterpretation of CDIO concepts at the semantic and cultural levels. From this perspective, CDIO is viewed as a variable educational context in which its value lies in stimulating the humanistic dimension and creative potential of design education, rather than simply applying engineering templates (Zha, 2008; Zhao, 2021).

The differences between the two types of thinking reflect the fundamental problem faced by the localization of CDIO: that is, how to maintain the systematic advantages of engineering education while avoiding the suppression of creative learning. This theoretical debate not only concerns the value orientation of design education but also provides a methodological basis for future teaching innovation.

2.2 Innovation in Curriculum and Teaching Models Based on the CDIO Concept

Research at the teaching level has, to some extent, moved away from the abstraction of theoretical frameworks and focuses more on “how to implement” practical strategies in the classroom. The core of the CDIO concept is to view the learning process as a simulation of a real project. Empirical studies of CDIO-inspired, project-based curricula show that organizing teaching around realistic engineering design tasks strengthens the connection between theory and practice and helps students develop interdisciplinary problem-solving competences (Huerta-Gómez-Merodio & Requena-García-Cruz, 2025; Yang, 2015).Its “projectization” and “task-based” features provide a new practical logic for design education. Students are not merely recipients of knowledge; instead, in the continuous practice of "design-implementation-operation", they gradually develop interdisciplinary integration capabilities.

Research highlights two main approaches to teaching. The first approach is called "task-chain teaching", which achieves a gradual progression of skill development through phased task modules. Multiple studies have shown that integrating competition tasks into curriculum design can help stimulate students' creative enthusiasm and problem-solving awareness (Zhao & Zhang, 2020). The modular structure of this approach makes the learning path easier to track (Chai et al., 2020). Consistent with this, Yu et al. (2017) and Zhang (2025) show that project-based design courses that embed enterprise competition cases within modularised project tasks can effectively cultivate students' innovation capabilities while supporting a clearer, stepwise progression of learning.The second approach is "collaborative co-creation teaching," emphasizing teamwork and mentorship in curriculum implementation. The introduction of the mentorship system enables students to experience the real design process by taking on different roles (Zhai et al., 2021). Additionally, the application of virtual simulation and digital platforms expands the scope and depth of learning opportunities (Yi, 2025).

Overall, this research direction indicates that the value of the CDIO concept is reflected not only in changes to teaching methods but also in the reorganization of the educational process. It prompts the classroom to transform from a static knowledge-transmission field into a dynamic knowledge-co-creation space, demonstrating the trend of the teaching transformation design education from "training" to "generation".

2.3 Professional Training System Under CDIO Orientation and the Construction of Industry-Academia Integration

At a higher level, CDIO is gradually regarded as a methodological tool for reconstructing the education system. Relevant research focuses on how to achieve vertical integration of ability development through course clusters and project chains, and on this basis, establish a collaborative mechanism between industry and academia. Existing achievements have shown that the CDIO framework can be used to build a progressive ability structure across courses and academic years. Studies have demonstrated that linking course clusters, project chains, and industrial platforms effectively bridges the gap between educational goals and industry needs (Gao, 2020; Wan et al., 2024).Through the linkage system of "course clusters - project chains - industrial platforms," it can bridge the gap between educational goals and industry demands.

Different scholars have proposed different approaches to enhance education: One type emphasizes "industry-academia integration," which involves embedding real-world enterprise projects into the curriculum. This enables the students to experience the entire process from design to implementation in a real environment (Jia & Dang, 2023). Another category advocates "competition-driven" approaches that focus on socialized assessments of learning outcomes through the integration of courses and design competitions (Zhang & Li, 2023). Additionally, some studies have also proposed the "multi-stage project cluster" model, which promotes the systematic growth of students' abilities through a structured project progression (Ma & Liu, 2023).

These explorations have enabled CDIO to extend beyond traditional classroom teaching, positioning it as an engine of institutional change and contributing to the systematic and industrialized development of transportation design education. However, empirical research on mechanism operation, resource allocation, and effectiveness evaluation is still relatively limited. Studies suggest that establishing long-term feedback mechanisms and fostering collaboration between academia and industry are essential for the sustainable development of the CDIO system (Wang, 2020; Jiang, 2014). Establishing a long-term feedback mechanism at the institutional level remains the key to the sustainable development of the CDIO education system.

A review of the existing research reveals that the development path of the CDIO concept in transportation vehicle design education follows a distinct phased pattern:

from theoretical development to teaching practice, and then to system integration. It not only provides a competency - based teaching model for design education but also encourages educators to reconsider the relationship between "design ability" and "engineering thinking". However, from a practical perspective, the localization of CDIO is still in the exploratory stage. The in-depth interpretation of theories, the structural optimization of the curriculum system, and the scientific construction of the assessment system remain important directions for future research. More importantly, the true value of CDIO may not lie in providing a complete set of teaching templates, but in inspiring educators to constantly seek a new balance between engineering rationality and design creativity.

3. The Construction Ideas and Framework Design of the Transportation Vehicle Design Curriculum System

The focus of education in transportation vehicle design is shifting from developing single styling skills to more comprehensive system design and engineering concepts. Although traditional teaching emphasizes aesthetic beauty and visual expression, there are often gaps in technical implementation, user experience, and manufacturing capabilities. In the face of the industrial background of intelligence and interdisciplinary integration, the reconstruction of the curriculum system has become a key issue in the reform of design education. Based on the CDIO framework as the theoretical foundation, this study proposes a "four-stage teaching model" for the design of transportation vehicles and mobile products, aiming to explore a training path that integrates creativity, engineering, and application.

3.1 Conception Stage: Guided Teaching Centered on Design Thinking and User Insight

During the conceive stage, the core objective of teaching is no longer confined to concept generation, but rather to cultivate students' ability to identify problems from a social and humanistic perspective through systematic design thinking and user research methods. The course structure draws on Stanford's five-stage design thinking process: empathy - definition - conception - prototype - iteration, and is localized and adjusted in combination with actual cases in domestic mobile scenarios (Zhang, 2020). Through observational research and behavioral analysis, students gradually master the path from observing phenomena to defining problems. Eye-tracking and virtual driving experiments were introduced into the classroom to simulate the driving experience of the elderly and people with limited mobility, thereby generating real behavioral data and providing a basis for barrier-free design.

The cross-disciplinary teaching that combines ergonomics and materials technology helps students understand the engineering constraints and manufacturability of design solutions. In terms of the assessment mechanism, the course adopts the CDIO Capability Maturity Model, which conducts a comprehensive evaluation based on three layers: theoretical understanding (40%), innovative exploration (35%), and practical expression (25%). The project outcomes are jointly reviewed by university and enterprise mentors to ensure that the teaching results can reflect industrial demands. The practice at this stage has verified the feasibility of interdisciplinary integration of the CDIO concept in design education, as shown in Table 1.

Table 1: Curriculum Framework for the Conception Stage

Element	Content	Process	Outcome
Teaching Objective	Cultivate students' design thinking and user insight, fostering a user-centered innovation mindset.	Empathy training, needs definition, and creative ideation workshops.	Concept sketches, design journals, and user insight reports.
Teaching Content	"Three-level integration" curriculum structure combining design thinking, user research, and design investigation.	Contextual inquiry, eye-tracking experiments, case analysis.	Research reports, prototype concepts, reflective summaries.
Teaching Practice	Case-based and contextualized teaching integrating technology and humanities.	Eye-tracking and virtual driving simulation combined with qualitative research.	Behavioral analysis data, accessibility design optimization proposals.

3.2 Design Stage: The Integration Practice of Modeling Language and Digital Modeling

The design stage focuses on three major components: modeling language, digital modeling, and scheme iteration. The course follows the main thread of "market insight - cultural translation - form innovation," requiring students to master visual expression while understanding the aesthetic logic in the cultural context. The basic course "AI and Product Innovation" guides students in studying the design language of classic vehicle models through reverse analysis. The advanced course "Future Mobile Design" enables students to integrate future travel trends and lifestyles, while incorporating user experience into styling concepts and spatial layouts. Digital modeling teaching adopts a "dual-track parallel" mechanism: one technical path is based on industrial software such as Alias and Blender, training students to strike a balance between accuracy and efficiency. Another project path is to complete the full-process experiments in clay modeling, rapid prototyping, and 3D printing through the school - enterprise collaboration platform. This double-line structure not only enhances students' engineering visualization ability but also maintains their material intuition and form perception in art design. Teaching practices during the design stage show that when digital technology and modeling logic are effectively coordinated, students' abilities in spatial understanding, form control, and interdisciplinary expression are significantly enhanced, as shown in Table 2.

Table 2: Curriculum Framework for the Design Stage

Element	Content	Process	Outcome
Teaching Objective	Cultivate students' ability in cultural translation and form innovation through the integration of art and engineering	Reverse analysis of classic cases, future mobility concept design	Design proposals, modeling sketches, and evaluation records
Teaching Content	"Three-track parallel" curriculum system integrating form language, digital modeling, and model iteration	AI-assisted form experiments, dual-track modeling with Alias and Blender	Stage models, 3D visualizations, iteration documentation

Teaching Practice	University–industry collaboration with multi-stage review mechanisms	Co-creation workshops, peer and expert feedback	Design evaluation forms, iteration reports, and final presentations

3.3 Practical Stage: Prototype Verification and Application of Virtual Reality Technology

The implementation stage focuses on verifying and executing the design outcome, establishing a closed-loop mechanism that combines virtual and real elements to comprehensively verify the chain. The course relies on 3D printing, Computer Numerical Control (CNC) machining, and reverse-modeling equipment to create a multi-level prototype practice system. The training focuses mainly on model replication and parametric modeling, while the advanced projects require students to complete the full iteration, moving from sketches to functional prototypes. The introduction of virtual reality (VR) technology has further broadened the possibilities of design verification. Students can assess the spatial proportion, interactive layout, and visual focus distribution in real time within an immersive environment. Some teaching units also combine eye-tracking data with VR models to help students revise their design plans based on concrete evidence (Li, 2021). Previous studies have shown that the virtual review mechanism can significantly reduce the cost associated with prototype production and improve decision-making consistency. This provides empirical support for the digital and intelligent transformation of design education for future vehicles. The teaching at this stage focuses on enabling students to understand the cyclical process of "design as verification", thereby achieving a dynamic balance among creativity, experimentation, and engineering, as shown in Table 3.

Table 3: Implementation Stage Course Framework

Element	Content	Process	Outcome
Teaching Objective	Cultivate students' ability in cultural translation and form innovation through the integration of art and engineering.	Reverse analysis of classic cases, future mobility concept design.	Design proposals, modeling sketches, and evaluation records.
Teaching Content	"Three-track parallel" curriculum system integrating form language, digital modeling, and model iteration.	AI-assisted form experiments, dual-track modeling with Alias and Blender.	Stage models, 3D visualizations, iteration documentation.
Teaching Practice	University–industry collaboration with multi-stage review mechanisms.	Co-creation workshops, peer and expert feedback.	Design evaluation forms, iteration reports, final presentations.

3.4 Operation Stage: Three-dimensional Synergy of Brand, Market and Management

The teaching content in the operation stage focuses on the commercialization and management practice of design outcomes. The course builds a complete training chain of "creativity - value - implementation" through the three-dimensional synergy of brand strategy, market transformation, and design management. Brand training focuses on differentiated positioning and international communication strategies. In combination with the "Automobile Brand Strategy" course, it guides students in constructing brand narratives using Eastern cultural symbols and developing communication strategies within the global market context. The market transformation stage introduces a "triple helix" collaborative model that includes universities, industry, and government, achieving the transformation of research results through real-world projects.

Additionally, a course on "Commercialization of Automotive Products" has also been developed, enabling students to understand budget constraints, cost structures, and operational logic within a real enterprise environment. The design management section emphasizes the dual development of "toolchain and process chain". At the analysis level, tools such as Strengths, Weaknesses, Opportunities, and Threats (SWOT) and Porter's Five Forces model are adopted. In contrast, at the process level, agile management mechanisms are introduced to enhance project response speed and decision-making efficiency. In addition, the course introduces Failure Mode and Effects Analysis (FMEA) and a full life-cycle traceability system for quality and risk control, enabling students to develop systematic thinking oriented towards industrial systems. This stage marks the transition of design education from an experimental approach to industrial application, leading to a structural transformation from "design teaching" to "design management".

Overall, the transportation vehicle design course framework, based on the CDIO concept proposed in this paper, has connected the cognitive, practical, and operational layers of design education, forming a closed-loop mechanism from conception to industry. This model not only balances engineering feasibility and human-oriented approaches but also provides a systematic reference for the future development of interdisciplinary design education. Future research can explore three directions: First, establish a multi-dimensional evaluation system for teaching effectiveness; Second, establish an industrial feedback and course co-creation mechanism; Third, explore the appropriate model for cross-cultural design education. Through these extended paths, the CDIO framework is expected to form a teaching paradigm with more international and local integration characteristics in transportation design education, as shown in Table 4.

Table 4: Curriculum Framework for the Operation Stage

Element	Content	Process	Outcome
Teaching Objective	Develop comprehensive abilities from creativity to business implementation, achieving integration between design and market	Brand storytelling, agile design management, and strategic thinking	Brand proposals, business strategy reports, exhibition works
Teaching Content	"Three-dimensional linkage" mechanism integrating brand strategy, market transformation, and design management	SWOT and FMEA analysis, design decision matrix, agile process control	Management reports, business concept models, product documentation
Teaching Practice	Practice system combining university–industry competitions and international exhibitions	University–enterprise–government collaboration, open workshop reviews	Market research reports, competition outcomes, and exhibition feedback

4. Teaching Practice and Analysis

4.1 Systematic Transformation and Differentiated Positioning of Transportation Design Education

In recent years, Chinese universities have gradually developed a teaching concept of "integration of design and technology and student-centeredness" in the field of transportation vehicle design education. Its core is no longer confined to simple training in form and expression, but instead attempts to strike a dynamic balance among artistic accomplishment, engineering thinking, and social insight. This change is particularly evident in the curriculum structure: teachers have begun to introduce systematic design thinking methods, interdisciplinary course clusters, and links to engineering practice, enabling students to pay attention to both conceptual innovation and technical feasibility simultaneously during the design process. Meanwhile, many universities are working to establish closer cooperative relationships with vehicle manufacturers, technology companies, and local industrial platforms to form an "industry-university-research-application" collaborative education system (Zhao, 2019). Compared with the previous closed model of the college, this mechanism has significantly improved in terms of project resources, data support, and the openness of the experimental platform. Some schools even introduce innovative topics such as intelligent connectivity, new energy systems, and human-computer interaction into teaching through joint laboratories or collaborative projects, enabling students to address industry's systemic challenges.

From a macro perspective, this transformation of the educational structure toward an industrial orientation has led to a significant shift in both the concepts and methods of teaching transportation vehicle design. Universities are no longer merely passively adapting to industries but actively participating in the construction of industrial ecosystems, promoting the regeneration and expansion of their own disciplines through innovative teaching practices.

4.2 Project-based Teaching Reform Based on the CDIO Framework

In higher design education, the CDIO educational model is recognized as an effective framework for promoting the simultaneous development of engineering thinking and innovation. In the localization process, Chinese universities have gradually transformed this model into a practical teaching system centered on project-based learning. The courses are mostly based on contextualized tasks and form a complete teaching loop that includes "demand insight - concept conception - digital model - solution iteration - verification and evaluation". Such a teaching design enables students to complete the entire process from problem definition to solution verification in an environment that closely resembles a real industrial process , as shown in Figure 2.

Figure 2: Teaching Case of BYD Global Automotive Design Competition

During the implementation stage of a project, students usually need to transform abstract design concepts into prototypes to assess engineering feasibility and verify them through means such as physical production, simulation, and augmented reality presentation. This process not only strengthens students' practical abilities and systems thinking, but also enables them to have a deeper understanding of the intrinsic logical relationship between design and engineering implementation. Previous studies have shown that combining project-based learning with evidence-based teaching strategies will significantly enhance students' teamwork skills and problem-solving abilities , as shown in Figure 3.

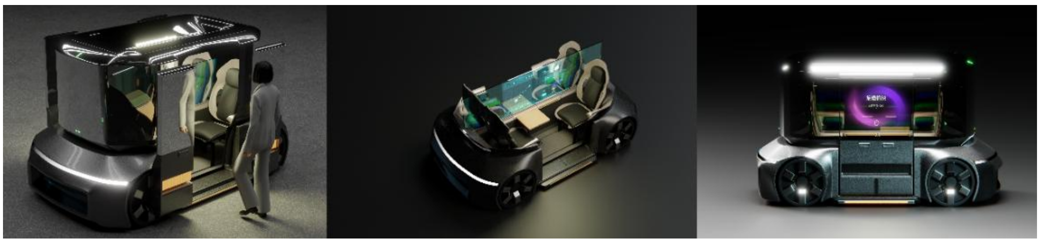

Figure 3: MoileLink Teaching Case

It is important to note that in the “Operate” stage of the CDIO framework, the focus of teaching extends beyond the mere design and implementation of products to include brand and market entry strategies and the development of business models. Students learn how to transform design outcomes into sustainable industrial value through means such as user research, brand positioning, and business feasibility analysis. This teaching design strengthens the connection between design education and innovation and entrepreneurship education, enabling students to possess both creative expression and business judgment abilities in their future careers.

4.3 Project-Driven and Interdisciplinary Education Ecosystem Reconstruction

The promotion of project-based teaching not only transforms classroom teaching but also drives deeper structural reform in design colleges. The “dual-core drive” teaching framework proposed by some universities is precisely a response to this trend: on the one hand, it centers on art and design, emphasizing the teaching in form expression, experience design and sustainable concepts; on the other hand, supported by engineering and technology, it integrates intelligent interaction, new energy and autonomous driving, among others, to create a comprehensive knowledge chain and practical system , as shown in Figure 4.

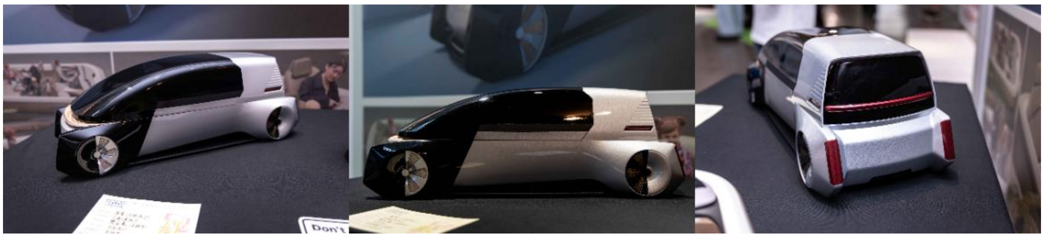

Figure 4: Teaching Case of Exterior Design for Mingxiao Driverless Car

This interdisciplinary integration is evident in the training program through a phased teaching approach that strengthens design thinking and technological ethics in early courses. The mid-term courses focus on plastic language, human-computer interaction, and digital modeling. The later courses emphasize testing the engineering feasibility and commercial potential of the solutions through prototype manufacturing, user verification, and market analysis. Some institutions even use real-world industry cases, such as Tesla’s electric vehicles, to guide students in analyzing the systematic relationships among minimalist design concepts, technological innovation, and brand strategies. This approach aims to enhance their interdisciplinary integration skills , as shown in Figure 5.

Figure 5: Teaching Case of exterior Design for Mingxiao driverless Car

In addition, school-enterprise collaboration projects have become a crucial way for students to connect with the industrial ecosystem. These projects help students form a closed loop of “theory - practice - innovation” in real design tasks, enhancing their comprehensive innovation skills and providing a foundational experience for future employment and research. Overall, project-based education is promoting the ecological transformation of the transportation design in colleges and universities, gradually shifting it from traditional art expression education to a multidisciplinary talent development model centered on systems thinking.

5. Conclusion

This study centers on the CDIO educational concept. It develops a transportation vehicle design curriculum that integrates engineering logic and design creativity, aiming to explore feasible pathways for integrating design education and engineering thinking. The course follows the "conception - design - implementation - operation" model as its main thread, integrating project-based learning, interdisciplinary content, and mechanisms for industry-academia collaboration. It is dedicated to cultivating students' systematic thinking, innovative awareness, and industrial adaptability, while also enhancing their professional competence and practical transformation ability in complex industrial environments. The research findings not only align with the core goals of the CDIO educational philosophy but also provide a practical, replicable model for transforming engineering education within the design discipline.

The core of the curriculum system focuses on deeply integrating design thinking with engineering logic through structured project-based teaching. The research divides the teaching process into five stages: "demand insight - concept conception - digital model - solution iteration - verification and evaluation," forming a complete design project process. This process not only simulates the real industrial development process but also strengthens students' abilities from idea generation to outcome verification. During the "conception" stage, the course guides students to combine design thinking with user research to identify complex travel problems. During the "design-implementation" stage, technologies such as digital modeling, virtual reality (VR), and prototyping are used to balance artistic intuition with engineering constraints. To align academic goals with industrial demands, this study introduces a capability maturity model and a multi-dimensional evaluation system for comprehensive assessment of learning outcomes that combines both quantitative and qualitative aspects.

In conclusion, the curriculum system based on the CDIO concept provides a systematic, scalable approach to reforming the transportation vehicle design education. Through continuous structural iteration and mechanism innovation, this model is expected to advance the engineering transformation of design education and its in-depth integration with industries. However, its long-term effectiveness still needs to be based on an evidence-based evaluation system, digital and intelligent tools, and ethical governance mechanisms to achieve sustainable development and innovative value in the future design of the education ecosystem.

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