

## *Original Paper*

# Exploration on the Teaching Reform Path of Steel Structure Course from the Perspective of New Engineering Construction

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### **Abstract**

*The new engineering construction takes the integration of production and education, digital empowerment and innovation cultivation as the core orientation, and puts forward new requirements for the comprehensive engineering practice, digital design and innovative problem-solving ability of talents. As a core compulsory course for civil engineering and intelligent construction, steel structure has the characteristics of theoretical abstraction, engineering practicality and industry frontier. The traditional teaching mode has been difficult to adapt to the talent demand of intelligent construction and assembly construction industry. Based on the long-term teaching practice of steel structure course, this paper combs the three outstanding problems of the current classroom teaching mode solidification, the separation of theory and practice, and the single evaluation system, and puts forward the systematic teaching reform scheme from the four dimensions of the reconstruction of teaching content, the integration of multiple teaching methods, the improvement of practical teaching quality and the improvement of the whole process of multiple evaluation system. The reform practice shows that the integration of digital teaching resources, the introduction of project-based engineering practice, and the establishment of a process-based assessment mechanism can effectively stimulate students' awareness of independent learning, strengthen students' BIM modeling, steel component design, and on-site construction coordination capabilities, and achieve the trinity of knowledge transfer, ability training, and value shaping.*

### **Keywords**

*New engineering, integration of production and education, steel structure, intelligent construction, teaching reform*

## 1. Introduction

### 1.1 Study on the Background

Since the implementation of the new engineering construction action plan of the Ministry of Education, domestic civil engineering colleges and universities have continuously promoted professional upgrading and transformation, and reshaped the talent training system for building industrialization, digitization and green transformation. Prefabricated steel structure, large-span spatial steel structure, high-rise steel frame and modular steel structure building have become the mainstream development direction of the industry. The market urgently needs compound engineering and technical talents who master the basic theory of steel structure, BIM digital modeling, on-site construction control, structural optimization and innovation.

“Steel Structure” is a core professional course of civil engineering and intelligent construction. The course covers the core contents of steel mechanical properties, connection structure, axial force components, bending components, compression-bending components, and overall design of steel frames. The formula system is complicated, the specification provisions are dense, and the spatial structure is complex. It has extremely high requirements for students’ mechanical foundation, spatial imagination, and engineering practical ability. Traditional classroom teaching is mainly based on blackboard writing theory, lacking engineering reality, digital simulation and on-site practical support. Students generally have learning difficulties of “understanding theory, not doing design and not understanding nodes”. There is a clear gap between the quality of talent output and the needs of industry posts. In this context, it is of great practical necessity to carry out all-round teaching reform of steel structure course based on the goal of new engineering education, to cultivate and cultivate diversified and innovative engineering talents who will lead the future development of science and technology and industry (Kong, Zhao, & Wang, 2021).

### 1.2 Research Significance

At the theoretical level, this paper combines the OBE results-oriented education concept to construct a teaching framework for steel structure courses suitable for new engineering disciplines, and enriches the theoretical system of digital and practical reform of civil engineering courses (Wang, Cai, Shao, Li, Wang, & Huang, 2022; Zhang, Chen, & Zuo, 2023). At the practical level, a landing and replicable teaching optimization strategy is proposed for the pain points of traditional teaching. Through virtual simulation experiments and school-enterprise joint project training, the shortcomings of practice are supplemented, the whole process assessment and evaluation mechanism is improved, and the students’ steel structure design, digital modeling and engineering innovation ability are effectively improved. Shorten the gap between university personnel training and enterprise employment needs, and help the high-quality development of local civil engineering industry.

### 1.3 Research Ideas and Framework

This paper follows the logic of “current situation analysis-problem attribution-reform path-practice summary”. Firstly, the three core teaching disadvantages of traditional steel structure course are sorted

out. Combined with the training standards of new engineering talents, a complete reform plan is designed from four aspects : integration of teaching content, integration of multiple teaching methods, improvement of practical teaching quality and reconstruction of assessment system. Finally, the effectiveness and optimization direction of reform implementation are summarized, and a complete teaching reform implementation system is formed. (Zhang, Li, & Jin, 2024; Wang, Tong, Zhang, Huang, Wu, & Cheng, 2026)

## **2. The Existing Outstanding Problems in the Teaching of Traditional Steel Structure Course under the Guidance of New Engineering Are Discussed**

### *2.1 The Classroom Teaching Mode is Single and the Cultivation of Students' Independent Innovation Ability is Insufficient*

At the present stage, most of the steel structure classrooms in colleges and universities still adopt the traditional teaching mode of “teacher blackboard teaching + PPT one-way output”. The teaching subject takes the teacher as the core, and the students passively receive the knowledge points. The form of classroom interaction is limited to simple questions and answers, and there is a lack of in-depth inquiry links such as group discussion, engineering debate and scheme comparison.

First, the degree of visualization of teaching carriers is insufficient. The failure modes of steel structure joints, component instability, and overall buckling rely only on two-dimensional drawings and static schematic diagrams. It is difficult for students to establish three-dimensional spatial cognition, and they have a vague understanding of the force mechanism of bolted connections, welding details, and beam-column rigid joints. Secondly, the teaching process lacks hierarchical design, and the unified teaching progress cannot take into account the students with weak mechanical foundation and excellent students with competition and scientific research potential, and the implementation of teaching students in accordance with their aptitude is not in place. Thirdly, there is a lack of innovative guidance in the classroom. The focus of teaching is on the recitation of normative provisions and the derivation of calculation formulas. There is no expansion task such as structural optimization and new steel structure scheme innovation. Students' innovative thinking has not been exercised for a long time, which is contrary to the goal of cultivating innovative talents emphasized by new engineering.

### *2.2 The Teaching System Emphasizes Theoretical Derivation and Neglects Engineering Practice, and the Theory and Practice Are Seriously Disjointed*

The steel structure course has both theoretical and strong engineering properties. The traditional teaching arrangement has obvious imbalance problems of “emphasizing in-class, neglecting extracurricular, emphasizing formula and neglecting practical operation”. First, the proportion of theoretical courses in class is too high, and the allocation of practical teaching resources is insufficient. A large number of class hours are used for the derivation of steel performance, stability coefficient and bearing capacity formula, while the class hours of component entity observation, virtual simulation experiment and steel structure design training are compressed. Students lack a complete training cycle

of hands-on calculation, modeling and drawing, and scheme optimization. Second, the lack of school-enterprise collaborative practice channels. Due to the limitation of site, safety and funds, the frequency of organizing students to visit steel structure processing plants and prefabricated building construction sites is very low. Students only rely on textbook cases to recognize engineering, and can not intuitively feel the whole process of steel component processing, assembly and hoisting. It is difficult to understand the engineering logic behind the provisions of the code. Third, the digital teaching content lags behind the development of the industry. Traditional teaching rarely integrates BIM modeling, parametric steel structure design, finite element simulation and other intelligent construction frontier technologies. After graduation, students can not quickly adapt to the requirements of digital design jobs, and their practical adaptation ability is weak.

### *2.3 The Evaluation System of the Course is not Perfect, and it is Difficult to Objectively Reflect the Comprehensive Ability*

The traditional steel structure course assessment adopts a single summative evaluation mode of “final written examination 70 % + usual homework 30 %”, and the assessment mechanism has obvious defects.

First, the assessment content focuses on theoretical memory. The test paper is mainly based on formula calculation and concept writing. It lacks practical assessment content such as engineering design, BIM modeling, and construction scheme design, and cannot test students’ engineering practical ability. Secondly, the weight of process assessment is low, and the usual performance only depends on the completion of homework. The learning process such as classroom discussion, group project, simulation experiment and field investigation is not included in the scoring system, and students’ enthusiasm for classroom participation and independent inquiry is insufficient. Third, there is a lack of hierarchical and diversified evaluation standards. The unified examination papers and unified scoring standards ignore the differences in students’ abilities, and cannot distinguish the ability levels of different dimensions of students’ basic mastery, practical operation and innovative design. The assessment results are difficult to objectively reflect the effectiveness of curriculum education, and cannot provide effective data support for teachers to dynamically adjust teaching programs.

## **3. The Implementation Path of Systematic Teaching Reform of Steel Structure Course under the Background of New Engineering**

Based on the four core requirements of “digitization, practicality, innovation, integration of production and education” in new engineering, aiming at the above three teaching pain points, this paper constructs a comprehensive teaching reform plan from four dimensions : reconstruction of teaching content, integration of multiple teaching methods, improvement of practical teaching quality, and construction of multi-assessment system in the whole process.

### *3.1 Integrate the Teaching Content of the Iterative Course and Build a Three-dimensional Knowledge System of “Basic Theory + Digital Technology + Engineering Practice”*

Combined with the current “steel structure design standard” and the development trend of the assembled steel structure industry, the original fragmented teaching content is reconstructed and integrated, the old and backward knowledge points are deleted, and the intelligent construction and green steel structure frontier modules are added to form a hierarchical progressive teaching content framework.

First, the basic theory module modular restructuring. By breaking the order of chapters in the textbook, the knowledge points are connected in series with the main line of “complete steel frame design project”, and the steel performance-connection design-axial member-bending member-bending member-bending member-overall stability is explained in turn. Each knowledge point is matched with small sub-design tasks, and the “theoretical explanation is synchronized with small engineering examples” is realized, and the boring teaching mode of pure formula derivation is changed. Second, add the characteristic content of digital intelligent construction. Embedding BIM steel structure modeling, Midas finite element simulation, parametric component optimization design teaching content, training students’ three-dimensional modeling, drawing deepening ability, and meeting the needs of enterprise digital posts. Third, integrate curriculum ideological and political education and industry frontier cases. The project cases of super high-rise steel structure, large-span venues and assembled steel structure residential buildings in China are integrated into the classroom, and the value guidance is carried out in combination with the development process of steel industry and the spirit of engineering craftsmen in big countries, so as to realize the organic integration of professional knowledge and ideological and political education. Fourth, supplement the green low carbon steel structure development content, combined with the national “double carbon” strategy, explain the design ideas of recyclable steel members and low energy consumption steel structure system, and broaden the students’ industry vision.

### *3.2 The Joint Application of Various Teaching Methods to Create an Innovative Classroom*

Abandon the single teaching mode, integrate the flipped classroom, project-based teaching, case teaching, virtual simulation, superstar classroom interactive multi-teaching methods, change the main body of the classroom, and promote students to shift from passive listening to active inquiry.

Flip the classroom pre-basic knowledge points. Based on the online learning platform, the micro-course video of steel performance, specification provisions and component foundation stress is uploaded. The preview task is arranged before the class, and the basic concepts are no longer explained repeatedly in the class. The class hours are concentrated on difficult discussion, case disassembly, design answering, and the depth of the class is improved.

Project driven throughout the whole course teaching. Set up a complete steel frame plant design project, disassemble it into four sub-tasks : node design, component bearing capacity checking, BIM modeling, and construction plan preparation. Complete the division of labor in the group as a unit, and run through the whole process of the course, so that students can fully experience the whole process of engineering design.

Virtual simulation makes up for the shortcomings of physical experiments. The virtual simulation platform of steel structure instability, weld failure and joint stress is introduced. Students can simulate the whole process of component loading through computer operation, and intuitively observe the buckling, fatigue and fracture failure modes, so as to solve the problems of high cost, irreversibility and poor visualization of physical experiments.

Superstar classroom real-time interactive precision teaching. Classes push multiple-choice questions and engineering case thinking questions, collect students' answer data in real time, accurately locate the weak points of class common knowledge, dynamically adjust the teaching rhythm, add group program mutual evaluation links, encourage students to compare steel structure design schemes from multiple angles, and cultivate innovative thinking.

### *3.3 Enrich the Carrier of Curriculum Practice, Improve the Practicality of Teaching Content and Classroom Interest*

Aiming at the problem of disconnection between theory and practice, a three-layer practical teaching system of "virtual simulation experiment + on-campus training + school-enterprise on-site practice" is constructed to make up for the shortcomings of practice in an all-round way, so as to enhance the interest of classroom and the enthusiasm of students' participation.

Improve the school steel structure training conditions. A steel structure component display training room was set up to display H-shaped steel, box columns, bolts, and weld specimens. A small-scale component bearing capacity measurement experiment was set up. Students measured the mechanical indexes of steel and made simple welded specimens to establish physical cognition.

Normalize the school-enterprise field practice. Establish long-term cooperation with local steel structure processing plants and prefabricated construction enterprises, organize 2-3 on-site visits per semester, and explain the steel component processing, rust removal coating, on-site lifting, and node splicing process by enterprise engineers.

Introduce interesting engineering comparison tasks. A group research task of "comparison of economy and construction cycle between concrete frame and steel frame" is set up. Students independently consult engineering materials, calculate cost, report results in class, stimulate students' interest in actively exploring professional knowledge, and solve boring problems in theoretical class.

### *3.4 Improve the Whole Process of Diversified Curriculum Assessment Methods, Scientific Evaluation of Comprehensive Learning Ability*

To break the single assessment mode of final written examination, a multi-evaluation system of "process assessment as the main and final assessment as the supplement" is constructed, covering the full dimensions of theory, practice, innovation and classroom performance. The assessment weight distribution is as follows : total score = online preview evaluation ( 5 % ) + classroom interaction and group discussion ( 10 % ) + training, simulation experiment report ( 15 % ) + curriculum design and BIM modeling results ( 20 % ) + final comprehensive written examination ( 50 % ).

First, enrich the content of process assessment. Online micro-course answers, classroom case

discussion speeches, virtual simulation experiment operation records, enterprise field research reports, and group project phased results are all included in the score, and the students' learning status is tracked throughout the course, so that students pay attention to daily learning. The second is to optimize the final assessment proposition structure, reduce the pure concept recitation questions in the written examination, increase the comprehensive application questions of complete component design, node force analysis, BIM drawing reading, and focus on the application ability of knowledge engineering. The third is to add an innovation bonus mechanism. Students who participate in steel structure-related discipline competitions, publish course papers, and complete new steel structure optimization schemes are given additional innovation scores to encourage students to take the initiative to carry out innovative practices. The fourth is to establish a two-dimensional scoring standard for students' mutual evaluation and teachers' comments. The group design project is completed by the team members' mutual evaluation. The teachers' comprehensive evaluation scheme is reasonable and innovative, and the assessment results are more objective and comprehensive, which truly reflects the students' comprehensive engineering ability.

#### **4. Analysis of the Implementation Effect of Teaching Reform**

First, students' learning initiative has been significantly improved. After the reform, the completion rate of online micro-course preview has increased from 56 % to 92 %. The participation of active speech in class and group discussion has been greatly improved, and the phenomenon of curriculum weariness and truancy has been significantly reduced. Secondly, students' comprehensive practice and digital ability are significantly enhanced. The quality of BIM steel structure modeling and independent design of complete steel frame is significantly improved. Students who go to steel structure enterprises can quickly start digital drawing and component checking. The feedback of enterprise tutors to students' post adaptation is greatly improved. Third, the discrimination of course assessment is more reasonable. The multi-assessment of the whole process can clearly distinguish the different levels of students' theoretical basis, practical operation and innovative design. Teachers can accurately adjust the teaching difficulties according to the assessment data, and the teaching pertinence is continuously optimized.

At the same time, there are still some problems to be optimized in the process of reform and promotion : first, some elderly teachers are not proficient in the operation of digital teaching tools, and there are differences in the quality of classroom implementation. Second, school-enterprise practice is limited by construction period and safety control, and the length of practice is difficult to fully meet the teaching needs. Third, the update speed of virtual simulation teaching platform lags behind the iteration of new technologies in the industry. The follow-up course team will continue to optimize the reform plan through the special training of teachers' digital teaching, the co-construction of off-campus long-term training bases, and the regular update of the simulation resource library.

## 5. Conclusion

Under the background of new engineering construction, the transformation of industry digitization and industrialization puts forward higher standards for the training of steel structure course talents. The traditional teaching mode of single theory teaching and summative assessment has been unable to meet the needs of the cultivation of compound innovative engineering talents. Aiming at the three core problems of steel structure course teaching mode solidification, disconnection between theory and practice, and imperfect assessment system, this paper constructs a complete teaching reform path from four dimensions : reconstruction of teaching content, integration of multiple teaching methods, construction of multi-level practice system, and improvement of multi-assessment in the whole process. Through project-driven engineering practice, BIM digital teaching, school-enterprise collaborative training, and whole-process evaluation mechanism, we can effectively open up the transformation channel from theoretical knowledge to engineering practice, and simultaneously cultivate students' engineering literacy, digital design ability and innovative thinking.

The follow-up course team will continue to deepen the integration of production and education, promote the iterative update of virtual simulation teaching resources, improve the hierarchical personalized teaching design, continuously optimize the quality of curriculum education, and provide more high-quality steel structure engineering and technical talents for the construction industry to meet the development needs of intelligent construction.

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