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Original Paper

Construction and Practice of Labor Education System for Civil Engineering Specialty Based on Structural Design Competition

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Abstract

Based on the requirements of the deep integration of labor education and professional practice in the new era, aiming at the problems of insufficient carrier of labor education and disconnection from engineering practice in civil engineering specialty, this paper constructs and practices a multi-dimensional labor education system with structural design competition as the core drive and through professional courses and competition training. The system decomposes the goal of labor education into five dimensions: value shaping, knowledge application, skill tempering, habit formation and quality cultivation, and implements it through the four-stage path of "curriculum embedding-school competition building-province competition tempering-national competition sublimation". Combined with the teaching of "Structural Mechanics", "Engineering Seismic" and other courses, the integration path of labor education elements in group projects such as bamboo bridge model bearing and multi-story frame seismic model is elaborated in detail. Practice shows that the system effectively stimulates students' enthusiasm for labor, significantly improves their engineering practice ability, innovative collaboration spirit and craftsman spirit, realizes the same frequency resonance of labor education and professional talent training, and provides a practical paradigm for similar colleges and universities.

Keywords

Structural design competition, labor education, civil engineering, craftsman spirit, curriculum integration, practice system

1. Introduction

Strengthening labor education is a key measure for colleges and universities to implement the fundamental task of moral education. “Opinions on Comprehensively Strengthening Labor Education in Colleges, Secondary and Primary Schools in the New Era” clearly points out that labor education needs to be closely integrated with disciplines and specialties to reflect the characteristics of the times. As an important engineering specialty supporting national infrastructure construction, civil engineering requires not only solid theoretical knowledge, but also rigorous engineering practice and lofty professional ethics. The traditional labor education mode is easy to fall into two major difficulties in civil engineering specialty: first, labor education is simply equivalent to public welfare labor or manual labor, which is “two skins” with professional ability training; the second is the lack of a stable, systematic and professional practice carrier that can carry the goal of comprehensive education (Ai, X. Y., Luo, Z. Y., Xie, Y. L. et al., 2025, pp. 127-132).

The national college students’ structural design competition and its selection competitions at all levels have become one of the most influential subject competitions in the field of civil engineering because of their comprehensive examination of students’ theoretical calculation, structural design, model making and teamwork ability (Shen, R. W., 2025, pp. 37-40). The whole process of the competition highly simulates the “design-build-test” link in engineering practice, and naturally contains rich elements of labor education: from the innovative conception of mental labor to the lean production of manual labor, from personal focus to teamwork, from the face of failure and frustration to the pursuit of excellent performance. This provides an excellent entry point for solving the above difficulties. Some domestic colleges and universities have begun to explore the combination of competition and labor education. For example, Dongguan University of Technology has incorporated labor literacy evaluation into the competition score, and set up special education for “big country craftsmen,” which has achieved positive results (Ai, X. Y., Luo, Z. Y., Xie, Y. L. et al., 2025, pp. 127-132). However, the existing practice mostly focuses on the organization and incentive of the competition itself, fails to place labor education in the teaching of professional courses, extends to the inheritance of competition culture, and has not yet formed a systematic system throughout the whole process of talent training.

Based on this, based on the long-term teaching practice of civil engineering major in Qingdao City University, this study constructs a set of labor education system with structural design competition as the main line and deep integration into professional course teaching, aiming at realizing the organic unity of labor value shaping, professional skill tempering and engineering ethics cultivation. The purpose of this paper is to systematically elaborate the construction logic, implementation path, curriculum integration examples and practical results of the system, in order to provide reference for promoting the deepening reform and innovative practice of labor education in civil engineering specialty.

2. The Core Construction Logic of Labor Education System: Five-Dimensional Goal and Four-Order Path

The core of this system is to follow the principle of "goal traction, path support, and full infiltration", and build the structural design competition into a dynamic and extended "practical education platform", rather than an isolated event activity.

2.1 Five-dimensional Labor Education Objectives

The system concretizes the goal of labor education in civil engineering specialty into five observable and cultivable dimensions:

1) Value shaping dimension: establish the correct concept of "labor creates engineering value", deeply understand the social responsibility of civil engineers to serve the society and ensure people's livelihood, and cultivate the craftsman spirit and engineering ethics of dedication and excellence (Gao, X. P., 2021, pp. 55-58).

2) Knowledge application dimension: To promote students to transform the theoretical knowledge of "structural mechanics", "material mechanics", "engineering seismic" and other courses into "know" to "use" in solving specific competition topics (such as bridge bearing, structural seismic), and to experience the value of mental labor (Liu, Chen, Yang et al., 2025, pp. 178-181).

3) Skills tempering dimension: through the fine processing of the model (cutting, grinding, bonding), train students' spatial perception ability, hands-on operation ability and modern tool use ability, and master "hand work".

4) The dimension of habit formation: in the repeated design-production-test cycle, cultivate students' professional labor habits of rigorous and meticulous, standardized operation, paying attention to safety and cherishing materials.

5) Quality cultivation dimension: In response to the challenge of the competition, time pressure and loading failure, students are honed in perseverance, innovation, unity and cooperation, and the pursuit of excellent psychological quality and willpower (Zhao, W., Zhang, S. Y., & Qi, J. Y., 2025, pp. 80-82).

2.2 Four-stage Progressive Implementation Path

In order to achieve the above five-dimensional goals, four stages of interlocking and progressive difficulty are designed (as shown in Figure 1):

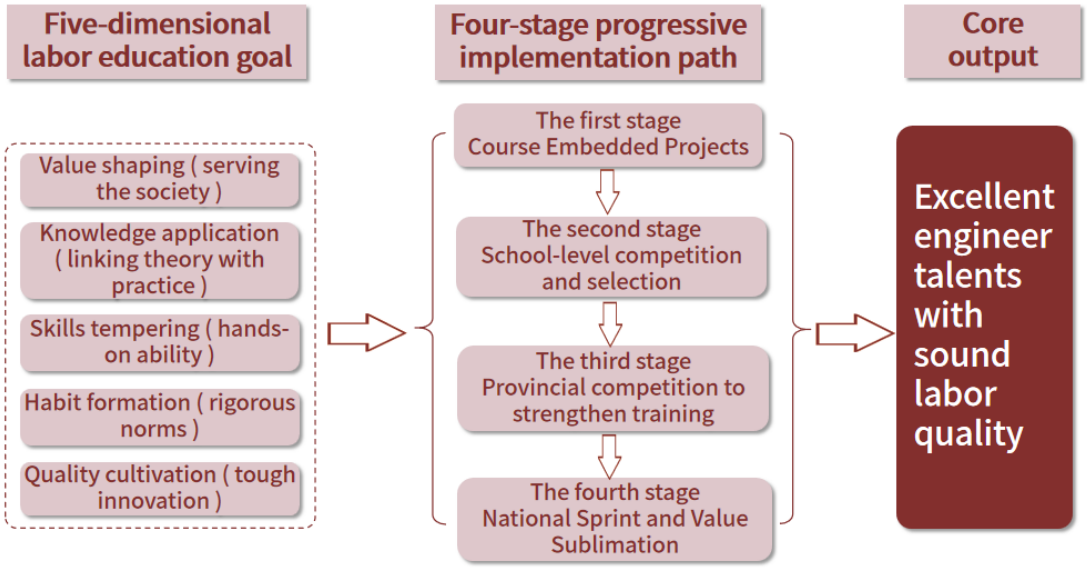

Figure 1. Implementation Path Diagram of Labor Education System of Civil Engineering Specialty Based on Structural Design Competition

The first stage: curriculum embedded project-labor consciousness enlightenment and knowledge exploration. In the core courses of "structural mechanics", "building architecture", "engineering seismic" and other professional core courses, the model design and production group tasks closely related to the core knowledge points of the course are designed. For example, after the truss structure chapter of "Structural Mechanics", the design project of "Lightweight High-strength Bamboo Truss Bridge" is arranged; in the course of "Engineering Earthquake Resistance," the design project of "seismic model of multi-story frame structure" is arranged. This stage focuses on stimulating interest, establishing the connection between theory and object, and initially experiencing the combination of design labor and production labor.

The second stage: school-level competition and selection-labor skills consolidation and standard establishment. The school-wide structural design competition is held regularly every year, and the topics can be derived from the course project optimization or simplified version of the provincial competition. Through the competition, create an atmosphere, the selection of seedlings. At this stage, the operation process and safety criteria are strictly standardized, the integrity of the model and the quality of the process are emphasized, and the students are guided to experience the "difference of millimetres, the error of thousands of miles" in the repeated optimization, consolidate the basic labor skills, and establish rigorous labor norms (Ai, X. Y., Luo, Z. Y., Xie, Y. L. et al., 2025, pp. 127-132).

The third stage: provincial competition to strengthen training-labor quality tempering and comprehensive application. For the provincial competition, the team selected by the organization was trained for several weeks. At this stage, the training intensity is high and the goal is clear. Students are

required to comprehensively use the knowledge of multiple courses to make and test high-precision and high-intensity models. In the process of continuous trial and error, adjustment and optimization, the students' working quality of facing difficulties, teamwork and continuous improvement is deeply tempered.

The fourth stage: national competition sprint and value sublimation-labor value recognition and spiritual guidance. For the team that has obtained the qualification of the national competition, a higher level of innovative exploration and extreme process pursuit is carried out. At this stage, by analyzing the cases of major national projects and interpreting the national strategic needs behind the competition questions (such as rural revitalization, disaster prevention and mitigation), students are guided to link their personal skilled labor with national development, so as to realize the sublimation of value recognition from "working for the competition" to "creating for the country," and internalize the sense of labor mission of science and technology to serve the country (Wang, M. Z., Gao, L., Yang, H. H. et al., 2025, pp. 214-217).

3. The Integration Practice of Labor Education in Professional Courses

The key to distinguish this system from simple competition training is to preposition labor education and integrate it into daily course teaching. The following are two typical examples of curriculum integration:

3.1 "Truss Bridge Model Design and Load-bearing Competition" in the Course of "Structural Mechanics"

After teaching the core contents of internal force analysis and influence line of statically indeterminate and statically indeterminate trusses, a three-week group project was introduced: using the specified specifications of bamboo bark, bamboo strips and glue, a simple supported truss bridge model with a span of 800 mm was designed and fabricated. The weight is not more than 200 g, and finally the centralized loading test is carried out (by applying weights in stages).

The integration points of labor education in this course are as follows:

1) Knowledge application: Students need to use the course knowledge to calculate and compare the internal forces of various truss forms, select efficient cross-sections, and complete the mental work from the calculation book to the design drawings.

2) Skills and habits: In the model making, students need to learn to use tools for precise cutting, grinding rod interface, control the amount of glue. The teacher emphasizes the safety of operation, the neatness of the work table and the saving of materials, and cultivates the standardized working habits.

3) Quality and value: The loading test is full of suspense. The joy of success or the frustration of sudden destruction are vivid educational opportunities. Teachers guide students to analyze the causes of damage (node failure or member instability? Compared with theoretical calculation, it not only deepens the understanding of knowledge, but also makes students realize the true meaning of engineering labor

that “rigorous calculation” and “fine construction” are equally important.

3.2 “*Multi-story Frame Structure Seismic Model Competition” in “Engineering Seismic Course”*

Combined with the teaching of seismic design theory, the project of “seismic model design of multi-layer bamboo frame structure” is set up. The model is required to have a certain height and floor mass, and tested on a simulated seismic vibration table. The final bearing capacity, stiffness and failure mode of the model are used as the evaluation basis.

The integration points of labor education in this course are as follows:

1) Value shaping: when the project was introduced, combined with domestic and foreign earthquake disaster cases, the extreme importance of seismic design to protect the safety of people’s lives and property was emphasized, so that students could understand the heavy social responsibility behind the design and production work they were engaged in.

2) Comprehensive application of knowledge: Students need to consider the seismic conceptual design principles of mass distribution, stiffness center, strong column and weak beam, joint reinforcement, etc., and transform the provisions on the book into specific structural layout and joint construction. This is a complex mental work that transforms theoretical knowledge into engineering decision-making.

3) Innovation and collaboration: In order to resist horizontal seismic action, students need to innovatively design various forms of support systems or energy dissipation devices. The team members collaborated intensively around scheme selection, division of labor production, test adjustment, and experienced the normality of team labor in engineering practice.

4. System Implementation Guarantee and Effectiveness Analysis

4.1 Implementation Guarantee Mechanism

1) The “double-qualified” guidance team: a guidance team composed of professional teachers (responsible for theoretical and value guidance) and student tutors with rich competition guidance experience (served by previous students, responsible for the teaching of technology and skills) is formed to ensure that labor education can be implemented at both the “Tao” and “skill” levels (Pu, Q. H., Fu, H. Y., Zhan, Y. L. et al., 2023, pp. 51-60).

2) The construction of “artisan workshop” platform: establish a dedicated structural design and model making laboratory, equipped with complete tools, materials and loading test equipment, create a real “engineering site” atmosphere, and become the substantive space of labor education.

3) Process evaluation system: reform the evaluation criteria of courses and competitions, not only to see the final loading results, but also to incorporate the process indicators of labor education, such as program innovation, calculation book quality, model technology, tool usage specifications, teamwork, safety and health habits, into the assessment, accounting for up to 30%-40% (Ai, X. Y., Luo, Z. Y., Xie, Y. L. et al., 2025, pp. 127-132).

4) The mechanism of achievement transformation and inheritance: the excellent curriculum project works, competition award-winning model, technology summary report, experience sharing video and other systems are sorted out to form a dynamically updated "competition-labor education" resource library for lower grade students to learn and realize the intergenerational inheritance of labor spirit and skills.

4.2 Analysis of Practical Results

After years of cyclic practice, the system has achieved remarkable results:

1) More than 80% of civil engineering students have participated in at least one course embedded model project or school-level competition. The questionnaire survey shows that 95% of the participants think that this way of "learning by doing and learning by competition" makes them have a deeper understanding of professional knowledge and labor value.

2) Engineering practice and innovation ability is significantly enhanced: students participating in the system training show stronger ability to solve complex engineering problems, drawing expression ability and hands-on practice ability in subsequent professional curriculum design and graduation design. In the past five years, students have won 7 national awards and 10 provincial first-class awards in the national and provincial structural design competitions, and the level and number of awards have been steadily improved.

3) Effective internalization of craftsman spirit and professional accomplishment: In follow-up interviews, students generally reflected that after many times of model making, they became "more patient and more careful", and had a near-instinctive pursuit of "precision" and "quality". Many graduates feedback, competition training to develop rigorous, collaborative, pressure-resistant quality, so that their workplace benefit.

4) The implementation of the system has forced teachers to update their teaching concepts and methods, promoted the project-oriented teaching reform of courses such as "structural mechanics" and "engineering earthquake resistance," and spawned a series of related teaching research papers and teaching reform projects, forming a virtuous circle of mutual feeding of educational achievements and teaching achievements (Yang, Z., & Xiao, L. L., 2025, pp. 140-143).

5. Conclusion and Prospect

This paper constructs and practices a set of labor education system for civil engineering specialty with structural design competition as the main line. The system clarifies the orientation of education through the "five-dimensional goal," provides an advanced ladder through the "four-step path," and innovatively integrates labor education into the teaching links of professional courses such as "structural mechanics" and "engineering earthquake resistance." Through specific bridges and frame model projects, labor education has a fresh carrier and a solid grasp.

Practice has proved that the system effectively solves the problem of disconnection between labor education and practice in engineering majors, and realizes the organic unity of labor education and professional knowledge teaching, engineering ability training and professional spirit shaping. It not only improves the comprehensive professional quality of students, but also subtly cultivates the craftsman spirit, labor feelings and social responsibility necessary for civil engineers in the new era.

In the future, the team will further deepen the research and practice of the system: first, explore the integration of modern information technologies such as BIM technology and digital twin into model design and labor process evaluation to improve the intelligence level of labor education; second, strengthen school-enterprise cooperation, introduce more real engineering micro-projects as competition topics or course cases, and enhance the fit between labor education and industrial needs; the third is to improve the long-term evaluation mechanism, track the development of graduates, and scientifically evaluate the long-term impact of labor education on their career growth.

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