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Exploration of Pathways for Cultivating Innovative Civil-Engineering Talents Empowered by Structural Design Competitions

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Abstract: Faced with industrial development trends including intelligent construction, green and low-carbon development, the civil-engineering industry has set higher requirements for talents' innovation capacity, practical capabilities and comprehensive qualities. Traditional talent-cultivation modes dominated by theoretical lectures can hardly adapt to the demands of the new era. As an important platform for practical-oriented education, structural-design competitions feature real-world tasks, complete workflows and strong comprehensiveness, which can effectively boost students' innovative thinking and engineering capabilities. Based on the realities of talent cultivation for the civil-engineering major, this paper analyzes existing problems in current innovation-oriented education, such as weak practical links, insufficient in-depth integration between competitions and teaching, inadequate mentoring capacity and poor achievement transformation. It explores implementation pathways for empowering innovative-talent cultivation via structural-design competitions from three dimensions: reconstruction of teaching-content systems, construction of training systems, and building of mentoring teams. Practices show that promoting teaching reform driven by competitions can effectively revitalize practical teaching, improve students' comprehensive capabilities and facilitate mutual progress between teaching and learning. It bears strong practical significance and promotion value for perfecting innovative-talent-cultivation systems.

Keywords: Structural-design competition; Civil engineering; Innovative talents; Practical teaching; Competence cultivation

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1. Current status of innovative-talent cultivation for civil-engineering majors

Against the background of the new era, most domestic universities offering civil-engineering programs have begun to attach importance to fostering students' innovative-practical abilities. They have gradually added practical-teaching modules to talent-cultivation schemes and encouraged students to participate in various discipline-oriented competitions, hoping to enrich forms of practical education through competition activities.

Nevertheless, there is still room for improvement in overall educational outcomes [1].

First, the construction of specialized practical-teaching links is relatively weak. Current practical content mostly relies on fixed teaching sessions such as course experiments and course design. Practical projects are relatively stereotyped, with task scenarios close to idealized conditions, which are different from the complex conditions of real-world engineering projects. When participating in practical activities, students mostly complete prescribed tasks following established procedures. They are given limited space for independent innovative design and trial-and-error exploration, and their initiative for active thinking cannot be well stimulated [2].

Second, the integration of competitions and teaching has not been thoroughly implemented. Some universities treat structural-design competitions as extracurricular second-class-room activities, which decouples competition work from in-class specialized teaching. Teaching content fails to match the capabilities required by competitions such as engineering design and model fabrication. Meanwhile, competition preparation does not feed back into in-class teaching reform. Only a small number of voluntarily enrolled students take part in competitions, so the educational benefits of competitions cannot radiate to the whole class [3].

Third, comprehensive mentoring capacity for competitions is insufficient. Structural-design competitions cover many aspects, including mechanical analysis, material selection, structural design, and technological fabrication, which place high requirements on mentors' cross-field engineering-practical experience. Some teachers possess solid theoretical-teaching foundations yet lack hands-on engineering experience and full-process competition-mentoring experience. Burdened by heavy daily teaching tasks, they can only devote limited time and energy to competition guidance, making it difficult to provide refined, whole-process mentoring for participating students [4].

2. Significance of empowering innovative-talent cultivation for civil engineering through structural-design competitions

2.1. Consolidate students' professional foundations and promote transformation from theoretical knowledge to engineering-practical competence

The civil-engineering discipline covers many abstract theoretical subjects such as structural mechanics, building materials and engineering structures. Relying merely on classroom lectures, students can hardly truly understand the applicable conditions of various theoretical knowledge in engineering scenarios [5]. Structural-design competitions deliver complete engineering-oriented tasks, pushing students to comprehensively apply professional knowledge learned from multiple courses into the development of complete structural schemes. The whole competition-preparation and participation process covers every phase: preliminary scheme conception, mechanical calculation and deduction, selection of suitable fabrication materials, physical-model processing and production, and repeated debugging and revision of model defects in later stages. This process serves as a systematic review and application of professional knowledge [6].

Instead of mechanically memorizing theorems in textbooks, students need to judge the applicable scenarios of different theoretical methods according to constraints of competition tasks, and weigh interrelations among structural performance, material properties and structural forms [7]. When dealing with practical problems such as model deformation and insufficient bearing capacity, students can further deepen their understanding of professional theories, bridge the gap between textbook theories and engineering

practice, and effectively improve core professional capabilities including engineering calculation, scheme design and hands-on operation, thus realizing substantial transformation from theoretical knowledge to practical competence.

2.2. Cultivate innovative thinking and comprehensive qualities to meet development demands for compound industry-oriented talents

Under the general context of intelligent and green construction, the civil-engineering industry demands a large number of compound talents equipped with innovative awareness, teamwork spirit and stress-resilient adaptability. Such comprehensive qualities can hardly be systematically cultivated through one-way classroom instruction [8]. Structural-design competitions are comprehensive team-based projects with no single standard answer. Instead, they encourage students to break inherent mindsets for innovative conception. Student teams need to complete topic demonstration and iterative scheme comparison on their own. When confronted with problems such as model failure and unsatisfactory scheme outcomes, they have to overturn original ideas and try new structural forms and material combinations, which fully stimulates students' innovative thinking [9].

In addition, competitions are generally carried out in team mode. Team members need to reasonably assign tasks, communicate with one another and negotiate over divergent opinions. While resolving internal conflicts, they jointly tackle various problems arising during competition preparation, which effectively cultivates their capabilities in teamwork, communication and coordination.

3. Implementation pathways for empowering innovative-talent cultivation for civil engineering through structural-design competitions

3.1. Reconstruct teaching-content systems and realize in-depth integration of competitions and teaching

To give full play to the educational value of structural-design competitions, the first step is to solve the decoupling between competitions and classroom teaching. Teachers shall integrate competition-related elements into daily specialized teaching and carry out competition-oriented education for all students, preventing competitions from becoming merely extracurricular activities for a small group of students. When revising talent-cultivation schemes, teachers shall adjust teaching emphases in accordance with knowledge modules and competence requirements involved in structural-design competitions [10].

For instance, in core theoretical courses such as Structural Mechanics, Building Materials and Concrete Structures, teachers may appropriately adopt typical competition cases as in-class teaching materials. When explaining theoretical knowledge points, they can illustrate practical application of theories with real competition-model examples. Meanwhile, topics for practical courses, including course design and course training, shall be adjusted. Some training tasks may draw reference from topic settings of structural-design competitions. Teachers can adopt open-ended engineering tasks to reduce requirements for standardized operations and grant students more opportunities for independent design and material selection [11].

Finally, establish layered and progressive teaching content. For lower-grade freshmen and sophomores, teachers may set basic popular-science content to popularize fundamental concepts of structural design and stimulate students' learning interest. For senior-year students, teaching content related to scheme innovation and model-fabrication optimization shall be added, so that students at different stages can receive corresponding cultivation.

3.2. Build a layered and progressive competition-training system and expand the coverage of practical-oriented education

To address the limitation of competition-participant groups and lack of systematic training for competition preparation, universities shall build a well-structured, step-by-step complete training system that balances universal popularization and cultivation of top-performing students, so as to cover the whole cultivation process from interest enlightenment to high-level competition preparation [12].

The first tier: universal enlightenment education for all civil-engineering students. Universities may carry out structural-design popular-science activities mainly via specialized student associations, thematic lectures and in-class practical training. Small-scale in-house model-fabrication experience activities can be held to help students perceive the fun of structural design and form preliminary practical cognition.

The second tier: training for university-level selection contests. For students with basic competence and willingness to participate in competitions, host intra-university structural-design selection contests. Students shall complete full-scale scheme design and model-fabrication contests in compliance with formal-competition task requirements. Intra-university contests serve as practice grounds for selecting potential student teams. Meanwhile, teachers shall provide basic guidance to familiarize students with the complete competition-participation workflow and help them accumulate practical project experience [13].

The third tier: intensive training for high-level competitions. Professional teachers may select outstanding students to form intensive-training groups and conduct targeted training for provincial- and national-level structural-design competitions. Teams shall carry out repeated polishing covering scheme demonstration, mechanical simulation analysis, material-process optimization and destructive model testing, guiding students to iterate and optimize schemes continuously. The layered-training system enables students of varying proficiency levels to obtain practical exercises matching their capabilities. It can realize both universal education and incubation of high-quality competition teams.

3.3. Improve practical-condition support and build mentoring teams to optimize supporting environment for competition-oriented education

Sound hardware-based practical conditions and high-quality mentoring teams are guarantees for the normal operation of competition-oriented education [14]. In terms of practical conditions, universities shall build student-oriented practical-training spaces, set up dedicated laboratories for structural-model fabrication, and equip tools and devices for model processing and simple mechanical testing. This ensures that students can access venues for model fabrication, assembly and testing after class, solving practical problems such as insufficient fabrication venues and testing conditions. Meanwhile, teachers shall coordinate consumables and practical-resource support, build reference resources for model-material selection, and provide basic conditions for students to explore properties of various materials independently.

In terms of mentoring-team building, establish diversified mentoring-teacher groups. Universities shall combine in-class theoretical teachers and practical-training teachers to form competition-mentoring panels, giving play to the respective strengths of each member. For example, theoretical teachers undertake mechanical-calculation and scheme-theoretical-demonstration tasks, while teachers rich in practical experience offer guidance on model-manufacturing techniques and debugging to guarantee overall teaching progress [15].

Furthermore, universities may organize exchange seminars for mentoring teachers, so that teachers can keep abreast of new proposition orientations of competitions and make up for insufficient hands-on engineering experience of some instructors. Appropriate introduction of industrial engineering-technical

personnel into mentoring work can bring real-world engineering perspectives and raise the overall standard of mentoring teams, providing sufficient intellectual support for students' competition preparation and innovative practice.

4. Conclusion

Characterized by engineering-oriented tasks, complete practical workflows and strong interdisciplinary comprehensiveness, structural-design competitions constitute an important platform for civil-engineering majors to implement practical education and cultivate innovative talents. Driven by discipline-oriented competitions, specialized-teaching reform can effectively revitalize practical-teaching sessions for civil-engineering majors. Students can achieve all-round improvement in professional competence, innovative thinking and comprehensive engineering qualities, while teachers' teaching and practical capabilities are also enhanced, realizing mutual advancement of teaching and learning. In future, universities shall keep up with cutting-edge technical developments in the civil-engineering industry, continuously improve integration modes between competitions and teaching, perfect innovative-talent-cultivation systems, and cultivate more high-quality innovative civil-engineering professionals for industrial development.

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