Journal of Education and Educational Research
ISSN: 2957-9465 | Vol. 20, No. 2, 2026

Exploration on Guidance and Teaching Reform of Structural Design Competitions Based on Structural Design Software

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Abstract: The National College Student Structural Design Competition is a comprehensive core academic event for civil engineering majors, which comprehensively examines students' comprehensive capabilities in mechanical theory, structural innovation, model fabrication, and engineering analysis. Conventional competition guidance relies on empirical trial and physical iteration, where students commonly suffer weak mechanical analysis, insufficient prediction of loading conditions, low material utilization, and high costs for model iteration. This paper takes four sets of competition models (triple wooden pagoda, impact-resistant concrete core bridge, vibration-resistant KuiRan Tower, and Wupeng Boat "SangSangSanni") from provincial competitions held between 2022 and 2025 as research carriers, and develops an integrated competition guidance teaching system centered on two finite element software packages: YJK and Midas Civil. A three-tier teaching implementation framework consisting of material property calibration, multi-condition numerical simulation, and physical model optimization is constructed. Differentiated simulation teaching priorities are specified for high-rise tower structures, impact-resistant bridge structures, and floating truss structures, and finite element simulation is fully integrated into courses including Structural Mechanics, Structural Experimentation, and Engineering Training. Teaching practices demonstrate that the software-integrated guidance framework cuts physical model iterations by 50% and bamboo material consumption by 40%, while significantly boosting students' proficiency in strength, stiffness, stability, and dynamic vibration analysis. Meanwhile, competition award rates and average comprehensive course scores rise synchronously. This paper summarizes the challenges encountered in software-assisted competition training and proposes solutions such as tiered software instruction, interdisciplinary joint training, and the development of a competition case repository, thereby providing a reference framework for reforming civil engineering practice courses.

Keywords: Structural Design Competition; Finite Element Software; Practical Teaching Reform; Bamboo Model.

1. Introduction

The National College Student Structural Design Competition has now become the largest academic competition held for undergraduate civil engineering students [1]. Each year, different design tasks are introduced in structural competitions including high-rise building structures, highway bridges, spatial structures and ships, shedding light on the use of bamboo wood as the primary material in the model construction. Unlike other contests participants in this competition must carry out all processes involved in the complete design cycle including conceptual design, material testing, numerical simulation, physical testing and load testing. [2]. Between 2022 and 2025, the Guangdong Regional Competition produced four representative tasks: a triple wooden octagonal pagoda, a two-section bridge under impact loads, a tower testing horizontal vibration, and a floating black-awning boat. The competing teams provided reports on calculation covering scheme comparisons, material testing, component testing, finite element modeling, mechanics analysis under various conditions and optimization of joints.

Guidelines for competition preparation have always leaned towards physical construction over numerical analysis. The majority of undergraduate students only create models based on their intuition and physical reconstruction, rather than using their quantitative knowledge of deformation, stress, and buckling theories under different loads [3]. The subjects covered in Mechanics of Materials and Structural Mechanics do not relate closely to actual model making, leaving students without the ability to recognize failure sites including tower cantilevers and bridge pier portion. Due to unavailability of systematic simulation routines, crucial parameters like dead weight, ultimate load bearing capacity, structural rigidity and vibration forces can only be measured after failure occurred, making it impossible to assess risks in the design stage [4]. According to the 2022 triple wooden pagoda calculation report, the first inner-outer two-tower scheme developed without the help of finite element analysis exhibited indirect force transmission, lot of material, and insufficient stability, which led to three complete physical demolitions and rebuilds before the single truss scheme could be finalized. In the same way, the 2025 prototype of the solid-hull Wupeng Boat did not pass the buoyancy simulation test, weighing a total of 230 g and failing the lightweight scoring tests, which meant two complete replicas and wasted bamboo and preparation time.

Software such as YJK and Midas Civil facilitates accurate numerical design of bamboo truss models to simulate all loading conditions that the prototypes experienced during the competition as axial stress, moment values, deformations, modes of buckling, and natural frequency [5]. Furthermore, stress concentrations, lateral buckling, vibrational breakdown,

and other forms of failure can be predicted at the design stage [6]. This study builds a complete competition guidance mechanism through finite element analysis based on four years of competition teaching practices. It reorganizes the civil engineering teaching courses and researches a unified teaching model for theory teaching, numerical simulation process, production process, and academic competitions [7]. The findings indicate the methods of software simulation teaching for each type of structure and calculate reform results while providing solutions for the issues faced during the teaching process [8]. All claims in the article are backed by experimental evidence, simulation charts and parameters taken from four years official competition calculation reports [9].

2. Persistent Drawbacks of Competition Guidance and Civil Engineering Practical Teaching

All four shortcomings of the traditional guidance model not based on simulation technology are presented based on four years of preparation records, official reports and students' feedback from 2022 to 2025.

2.1. Disconnection Between Mechanical Theories and Structural Design, Blind Empirical Trial-and-Error

Lower-grade students only master fundamental tension, compression, and bending theories for single members, lacking proficiency in torsion, dynamic vibration, and transient impact analysis. Structural schemes are determined purely by visual intuition. The 2022 triple wooden pagoda's early inner-outer tower design and the 2024 four-story KuiRan Tower prototype were both developed without numerical calculation, relying on the misconception that "more members equal greater stability". The prototypes did not have proper compression columns or enough upper-floor stiffness and were subjected to more than two months of continuous testing and further alterations. Students don't grasp the difference between axial members and flexural, causing massive waste in bamboo of secondary connections resulting in the material utilization that stays less than 30%, which does not comply with the competition scoring criterion.

2.2. Absence of Standardized Material Databases, Large Deviations Between Simulation and Physical Test Results

Bamboo is anisotropic material whose physical and mechanical properties differ significantly depending on the sheet thickness and cross-sectional shape used. Conventional teaching methods of bamboo properties neglect the importance of standardized tensile testing procedures, causing the values of different materials to be assigned randomly. All four competitions use the same method of tensile testing on bamboo material to create their reports. Bamboo sheets from 0.2 mm thick to 0.7 mm thick have an elastic modulus of 6,000 N/mm² and a tensile strength of 60 N/mm² while solid and box bamboo bars from 2 mm thick to 6 mm thick demonstrate varying strength properties. Competitors who do not follow this method of material calibration struggle, as they encounter discrepancies of over 50% between their simulated and experimental ultimate load values.

2.3. Segregated Curriculum Modules Without Supporting Competition-Oriented Training

Civil engineering studies are fragmented into different modules like Mechanics of Materials, which is based on theory alone and does not include any practical modeling tasks. Finite Element Basics only focuses on analyses of concrete and steel frames whereas no training is provided on bamboo trusses. Structural experimentation only examines industrial prototypes and ignores any practical prototypes used in competitions. There is no complete module available to train participants for structural contests. Due to the fact that students do not get to experience modeling with competitive conditions such as multi-stage loading, clearance areas, and weight restrictions, they don't make a connection between what they learn in class, and the things they do while participating in various competitions.

2.4. Unpredictable Multi-Load Risks Only Detected After Physical Structural Failure

With each passing year, advancements in competition loading conditions become more sophisticated: The pagoda in 2022 used vertical random loads with two layers and torsion as well as horizontal force on the second floor; the bridge of 2023 used moving trolley loads in both directions and impacted on the pillars; the skyscraper of 2024 made use of harmonic vibrations in the range of 3-5 Hz; and lastly, the vessel from 2025 used static loads with staged impact due to rigging. Prior numerical simulations are not used prior to discovering structural hazards. With the occurrence of lateral buckling of pagoda overhangs, pier fracturing under impact, resonance collapse of tower tops, or bending depression of mid-hulls, the only time defects are detected is after they have become irreversible.

3. Construction of Integrated Competition Teaching System Centered on Finite Element Software

This research adopts YJK and Midas Civil, which are prominent finite element software in the industry, to address the limitations mentioned above. In this regard, a three-step progressive teaching model comprising the aspects of basic material calibration, multi-scenario numerical modeling, and physical process improvement has been developed which combines mechanical theory, laboratory experiments, numerical modeling, and practical fabrication together.

3.1. Fundamental Tier: Standardized Bamboo Material Testing and Software Parameter Calibration

The module is part of the Structural Experimentation program and consists of four class hours for simulating the testing process represented in reports from the four years of this study. Tensile tests are performed with clamping fixtures and increased loads until the break of the test sample while noting the highest forces for calculating elastic modulus and tensile/compressive strengths. Five typical shapes are represented. Students have to input measured material parameters in FEM system without using arbitrary values. Important aspects of the software such as creating nodes,

defining the cross-section, applying constraints, applying loads, and meshing are discussed and assigned as crucial tasks, with the idea of learning the software through modeling a truss as a homework task.

3.2. Core Tier: Modular Simulation Teaching Classified by Structural Type

Two independent software teaching modules are created with different application areas and priorities regarding their analysis following task requirements. The five important aspects of the analysis include strength, stiffness, stability, dynamic vibration, and stability of floating bodies (Table 1).

In the three-stage competition loading procedure, simulation does not overlay all loads at once as Stage 1 involves modeling of loads separately in order to establish a stress and deformation baseline; Stage 2 involves loading of additional loads and observation of stress increases induced by the impact or twisting; and Stage 3 is concerned with extreme fast-moving loads to assess the risk of resonance and overturning. To find structural point of stress concentration, five standard output diagrams (axial force diagram, bending moment diagram, displacement diagram, buckling mode diagram, and natural vibration time diagram) are made into standardized simulation reports that form the central part of official competition work.

Table 1. Comparison of Simulation Teaching Modules for Two Finite Element Platforms

Software	YJK	Midas Civil
Applicable Competition Prototypes	Octagonal wooden pagodas, vibration-resistant high-rise towers	Impact-resistant bridges, floating Wupeng boats
Core Analytical Modules	Static strength, stiffness, eigenvalue buckling, time-history vibration	Axial force & bending moment analysis, deflection calculation, impact time-history, floating body initial stability (GM value)
Key Simulated Competition Loading Conditions	Multi-story random vertical loads, horizontal torsion, graded harmonic excitation, lateral static loads at tower tops, buckling mode identification	Moving trolley live loads, fixed-point impact forces, staged static hull loading, navigation inertial forces, hull torsional resistance

Simulation strictly follows the three-stage competition loading sequence without simultaneous superposition of all loads: Stage 1 loads are modeled independently to extract baseline stress and deformation data; Stage 2 supplementary loads are overlaid to observe stress increments induced by torsion or impact; Stage 3 extreme dynamic loads are applied to predict resonance and overturning risks. Five standard output diagrams (axial force plot, bending moment plot, displacement contour, buckling mode, natural vibration period) are generated to quantitatively locate structural stress concentration zones, forming standardized simulation reports as the core chapter of official competition calculation documents.

3.3. Application Tier: Physical Model Size and Joint Optimization Guided by Simulation Results

After completing numerical analysis, students implement two categories of physical optimization based on simulation cloud diagrams:

Cross-section lightweight optimization: For low-stress, secondary connecting bars, 2×2 mm solid bamboo sections are used. On the other hand, heavily loaded compression columns and flexural overhangs/piers are made with 7×7 mm box cross-sections with thickened walls. In doing so, the self-weight is kept to a minimum keeping the required strength for the maximum load-to-weight ratio. Through the YJK simulation optimization, it was estimated that the total weight of the 2022 triple wooden pagoda is 270 g, which is 42% less than the original inner and outer twin tower model.

Targeted Joint Reinforcement for Stress Concentration Zones: A well-known bonding process, used for the last four years of competition reports, is applied: mixing bamboo powder and adhesive helps to make surfaces rough enough, controlling adhesive thickness (0.05–0.1 mm), and maintaining preload during curing to avoid the occurence of internal voids. The critical joints are reinforced with thin bamboo sheets absorbing all loads and avoiding joint failure or member breaking, including tower tips, column foundations, overhang connections, bridge piers, and middle hull. The dimensions of joints are fully fixed according to numbers received from simulation, providing highly precise sizes, which is accurate within ±5 mm.

4. Practical Simulation Teaching Cases for Multiple Types of Competition Prototypes

Based on comprehensive reports for calculations given for the years 2022 - 2025, simulation methods for three typical structural types of construction (high-rises, shock-resistant bridges, floating structures) are demonstrated through the complete cycle of the structural design process using finite element analysis software.

4.1. Simulation Teaching for High-Rise Tower Prototypes

The 2022 and 2024 tower tasks both feature heights of 1,000–1,050 mm and incorporate vertical staged loads, horizontal static forces, torsion, and harmonic vibration, all analyzed via YJK software in teaching sessions.

4.1.1. Simulation-Driven Structural Scheme Screening

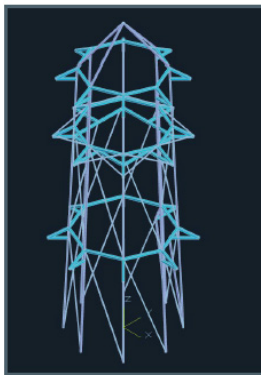
Both designs were tested under the same material and loading conditions. The twin tower design was proven not to work as it showed indirect load transmission, the lowest forces in the internal bars, and high dead weight. Hence, this design was dismissed without any physical realization. The single truss design with stringers on the first floor showed very low deformation and was selected as a prototype. The vibration tower designs, four-story and five-story cross-section alternatives, were evaluated for performance. The four-story tower had significant flexibility but also very low natural frequency of 5 Hz. The five-story tapered cross-section was able to get over the 3-5 Hz frequency range. Thus, the five-story model was chosen as the preferable option. The simulation studies helped to save two weeks of fabrication time.

4.1.2. Multi-Condition Mechanical Analysis and Weak Zone Identification

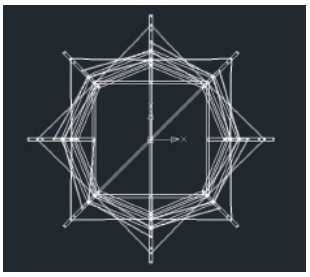
Under Stage 1 vertical loads, tower overhangs have bending and buckling moments. Stage 2 involves the use of horizontal torsional loads, inducing tension in the diagonals of the second floor of the tower, which can be optimized. Stage 3 includes horizontal and vibration loads imposing maximum compression in the columns of the first floor of the tower. First-floor beam-column connections and overhangs are identified as critical failure zones. Time history vibration analyses determine the natural periods of the structure, forming the basis for the use of lateral diagonal tension bars and floor height modifications.

4.1.3. Physical Fabrication Derived From Simulation Data

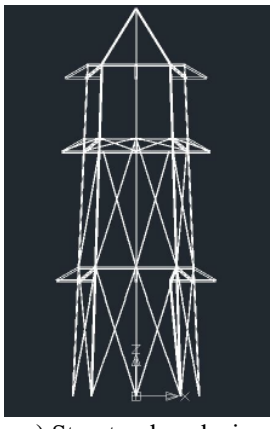
According to the simulated stress shape, the cross-sections of metal sections are made of concrete where load-bearing base columns are given box shapes and a wall thickness of 0.5-0.7 mm, while upper secondary diagonal bars are made of light solid strips of dimensions 2 x 2 mm. Grade beams are placed on all cantilevers, in order to prevent bending. The joints between the tower tip and the column base are reinforced with wedge gaskets and adhesive joints filled with bamboo powder. After optimization that used vibration, the 2024 KuiRan Tower has passed the tests at 3 Hz, 4 Hz, and 5 Hz without exceeding the displacement of 25 mm.



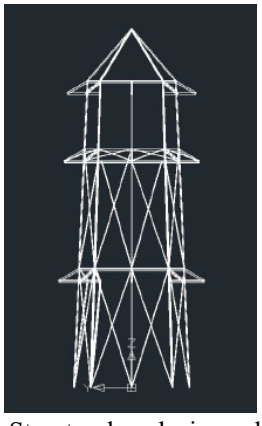
a) Structural analysis model 3D axonometric view



b) Structural analysis model plan

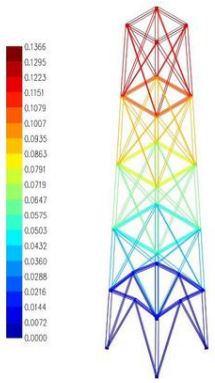


c) Structural analysis model elevation

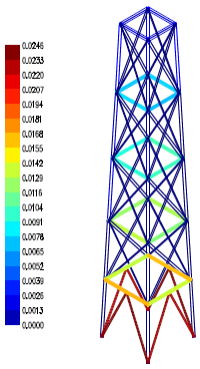


d) Structural analysis model side view

Figure 1. 2022 Competition wooden tower structure 3D model



a) Tower structure displacement contour



b) Tower structure stress contour

Figure 2. 2024 Competition tower structure 3D model

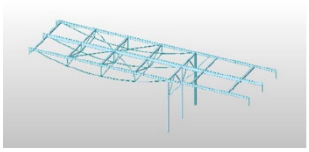
4.2. Simulation Teaching for Impact-Resistant Bridge Prototypes

The 2023 bridge task involves moving trolley live loads and fixed-point sphere impacts in Midas Civil using transient time-history analysis. Four different schemes were analyzed for their performance, and the best was selected.

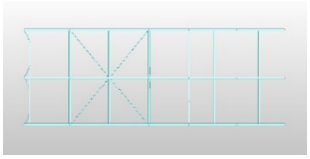
4.2.1. Quantitative Comparison of Four Bridge Schemes

Considering the fact that lattice box piers offer greater bending and shear resistance, a numerical comparison with solid square tube piers has been made. Diagonal V-buffers are used on piers for the purpose of spreading out transient impact force while a series of cables suspended under the bridge deck are used to balance downward bending moments arising due to moving load.

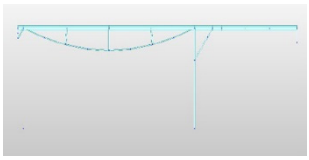
4.2.2. Targeted Optimization for Impact Loading



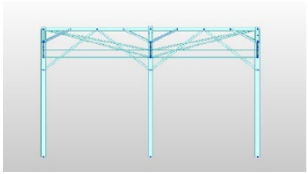
a) Structural analysis model 3D axonometric view



b) Structural analysis model plan



c) Structural analysis model elevation



d) Structural analysis model side view

Figure 3. 2023 Competition bridge structure 3D model

4.3. Simulation Teaching for Floating Wupeng Boat Prototypes

In the floating vessel task of 2025, hull flotation stability analysis was presented as part of the multidisciplinary civil-hydraulic engineering module supported by Midas Civil for simultaneous calculation of structural stress and metacentric height (GM). Numerical analysis provided data for three different hull configurations: solid full-section hull, thin-web light truss, and mid-hull string truss.

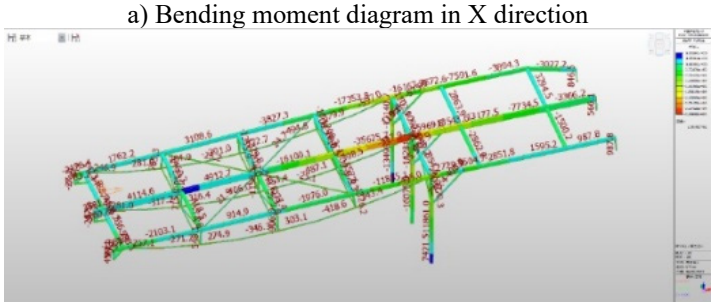
4.3.1. Combined Lightweight and Flotation Stability Simulation

The solid full-section hull provides great stiffness, but its weight of 230 g hurts lightweight scoring. The thin-web light

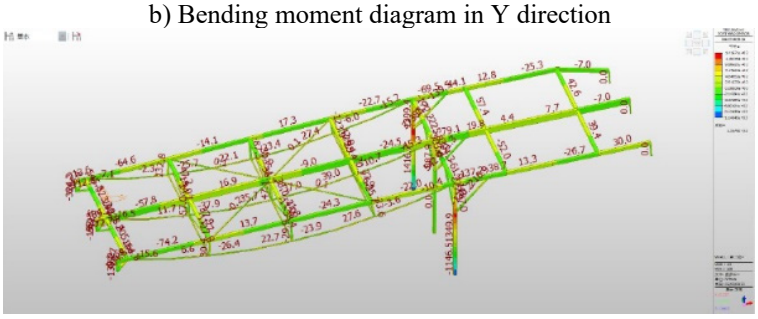
truss provides a weight of 65 g but suffers from weak hull side bending resistance under Stages 3 loads. The mid-hull string truss prototype weighs 80 g, providing a balance between bottom truss stiffness and lightweight performance and meets minimum GM anti-overturning stability requirements making it the best option.



a) Bending moment diagram in X direction



b) Bending moment diagram in Y direction



c) Bending moment diagram in Z direction

Figure 4. 2023 Competition bridge structure mechanical analysis diagram

4.3.2. Deformation Analysis Under Staged Static Hull Loading

At Stage 1, there are concentrated bending moments at the bow due to the single-side seat loading, hence additional transverse support bars are required. At Stage 2, there are high localized central cabin loads causing excessive mid-hull deflection that are solved with cross ribs. At Stage 3, the cumulative effect of added loads and inertia of navigation causes unnecessary global torsional deformation, resolved by closed truss rings on the hull sides. Simulation reveals that the cabin midsection is the area of deformation which requires reinforcement.

4.3.3. Unique Teaching Content for Floating Prototypes

The basic principles of ship hydrostatics are taught to illustrate the anti-overturning principles, and as a result, this method is innovative and connects civil engineering with hydraulic engineering. The roof of the modular cabin has been developed and tested by simulation to comply with the rules of flexible loading.

5. Curriculum Reform Supported by Competition Simulation Training

Taking software-aided contest preparation as the core driver, integrated reforms are implemented for four core civil engineering courses: Mechanics of Materials, Structural Mechanics, Finite Element Fundamentals, and Structural Experimentation, covering curriculum restructuring, teaching methodology, training resource development, and assessment mechanism revision.

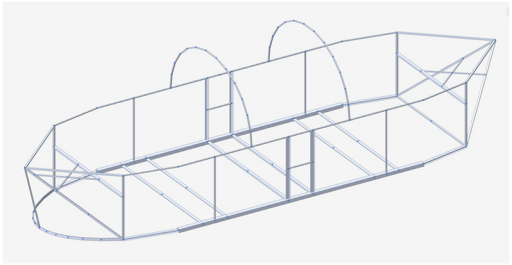
5.1. Restructure Curriculum and Add Dedicated Competition Simulation Training Modules

The existing siloed content is eliminated and an essential 32-hour complete course Finite Element Simulation for Structural Design Competitions is created for junior students in their second semester, which consists of three stages: 8 hours of bamboo material testing and introduction to software, 16 hours of modeling for the competition purposes, and 8 hours of report writing. A variety of topics such as truss mechanics, structural stability, dynamic response, and impact analysis are compiled together and examples in class represent production prototypes from the bamboo competition between 2022 and 2025.

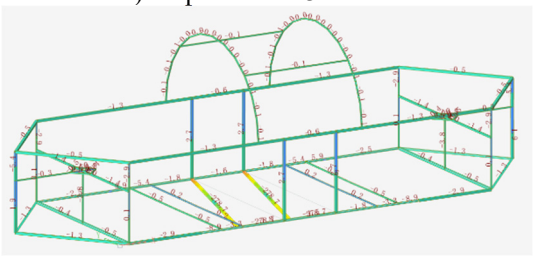
5.2. Adopt Project-Based Learning (PBL) With Historical Contest Tasks as Teaching Projects

Four key teaching tasks are to be done by four students in accordance with four years of competition activities. The following steps have to be followed: reading contest rules, sketching a design scheme, testing bamboo, modeling with

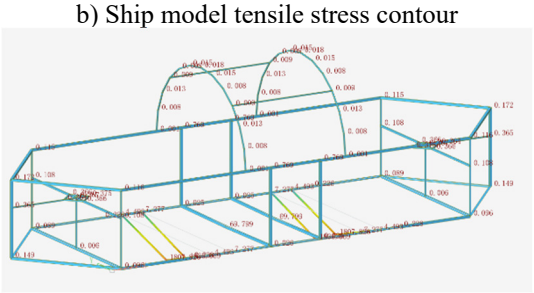
finite, doing cross-section and joint studies with simulated contours, making drawing of the detail and calculating the theoretical result. The process faithfully replicates civil engineering design methodology, in which students earn graded deliverables in the form of finite element files, experimental data, and competition accounting reports instead of written homework.



a) Ship structure 3D model



b) Ship model tensile stress contour



c) Ship model deformation diagram

Figure 5. 2025 Competition software analysis diagram

5.3. Develop Standardized Shared Competition Training Resource Library

Four categories of shared teaching resources are compiled from four years of teaching accumulation:

Bamboo mechanical property database, containing tensile test data for all commonly used competition members for direct student reference;

Standard finite element model source files (YJK & Midas Civil) for all four prototype types, serving as reference templates for new students;

Top-tier official calculation reports formatted per JEER journal standards, standardizing formatting for charts, formulas, and loading condition descriptions to improve students' technical document writing proficiency.

All resources are shared online for after-class self-directed training.

5.4. Overhaul Comprehensive Course Assessment Mechanisms

Single final written examinations are replaced with a multi-dimensional evaluation framework weighted as follows: theoretical written exam (40%), finite element simulation modeling (30%), competition calculation report writing (20%), physical model loading test (10%). Simulation, technical writing, and physical fabrication components directly align with competition evaluation standards, reversing the overemphasis on rote memorization in traditional assessment. Students not participating in national contests complete the curriculum project model as their final assessment, while competition participants may substitute their official contest submissions for training coursework.

6. Quantitative Analysis of Teaching Reform Outcomes

Control groups (without simulation) and experimental groups (reformed teaching) were monitored from 2022 to 2025 to determine the reform impact on preparation efficiency, prototype performance, and student competency metrics.

6.1. Optimized Preparation Efficiency and Reduced Material Costs

Normal practice necessitates using 3 to 4 physical prototypes for testing, costing about $26 per group for materials. Optimization before testing helps to reduce the need for physical prototypes to 1 to 2, which reduces expenditure on materials to less than $15, as well as reduces preparation time to 60 to 32 days (by 47%). Using the 2025 Wupeng Boat as an example, the control groups had to create three full hull prototypes for testing, while experimental groups had to create only one prototype using numerical optimization.

6.2. Comprehensive Improvements in Competition Prototype Performance

Identical-task prototypes from pre- and post-reform cohorts are compared on four key metrics:

Lightweight performance: Average load-to-mass ratio increased by 37% via simulation-driven elimination of redundant members;

The ultimate bearing capacity: The max load allowed increased 28% after the reinforcement of weak areas before the trial and reduced the risk of infrastructure failure during the test;

Managing rigidity: The max shift that occurred throughout all tests was reduced by 31%;

Complex multi-condition pass percentage: The figures for combined load vibration, torsion, and the impact increased from 62% to 94%.

Gaining awards at first and second provincial competitions increased by 56% throughout the four years of transformations.

6.3. Improved Student Comprehensive Professional Competency

After the reforms, participants in Structural Mechanics post-final exams show 12.3 score increases, indicating better skills in advanced topics such as structural stability, dynamic response, or impact mechanics. The post-course survey shows that 91% of students are able to carry out multi-condition truss modeling and analysis independently with the help of YJK or Midas software, while 87% manage to write engineering calculation reports without assistance. The simultaneous development of numerical modeling skills, technical writing skills, and manual skills allows students to implement abstract theories in practice and offer combined theory and practice.

7. Persistent Teaching Shortcomings and Long-Term Optimization Strategies

Four years of teaching practice revealed three core limitations: tiered learning gaps, insufficient depth of dynamic simulation instruction, and weak cross-disciplinary integration. Targeted long-term improvement measures are proposed accordingly.

7.1. Existing Teaching Limitations

High entry barriers for unqualified learners: first- and second-year students do not possess fundamental knowledge of the structural mechanics subject and keep erroneously applying the boundary and loading conditions during multi-condition simulation and ineffective studies.

Limited scope of dynamics and impact training: The limited number of hours of lectures provides inadequate coverage of time-history analysis in general, resonance, and transient impact parameters, making it difficult for students to deal with complex dynamic load problems.

There is lack of implementation of cross-disciplinary knowledge: Ship hydrostatics is required for floating vessels, while bridge impact evaluation requires knowledge of impact dynamics. Civil engineering programs don't provide students with skills necessary for both fields.

7.2. Long-Term Optimization Implementation Strategies

Create tiered micro-lectures: Three levels of learning are distinguished; first-year static truss simulation, second-year static modeling in various conditions, and third-year advanced dynamic/floating body simulation. Micro-lectures will take place before the session, while the lecture will focus on solving complex exercises.

Launch a short dynamic simulation training before the competition: Conduct an intensive workshop for 8 hours every year before provincial competitions to train young engineers on vibration and impact loading cases using knowledge learned in the previous year's event.

Cross-specialization activities: Partner with hydromechanics faculty for the floating structures courses and with impact mechanics instructors for seminars to cover interdisciplinary knowledge gaps.

Annual updates of case library: The finite element files, calculation reports, and loading test videos are uploaded yearly after each competition to ensure correspondence of pedagogy to the changing trends in contest design.

8. Conclusion

The National College Students' Structural Design Competition serves as a core practical platform for meeting engineering education accreditation requirements and is a fundamental means of cultivating civil engineering students' hands-on skills and innovative abilities. Traditional trial-and-error-based guidance methods suffer from issues such as low preparation efficiency and a disconnect from mechanical theory. The structural defects are often not discovered until after the competition, making it impossible to optimize the design in a timely manner. By integrating mainstream finite element software into the competition coaching process, a teaching framework of "materials testing—numerical simulation—physical optimization" has been established. This new hands-on teaching approach addresses the issue of delayed feedback inherent in traditional methods.

The model was validated using experimental data from 2022 to 2025, covering four types of prototypes: high-rise towers, impact-resistant bridges, and floating vessels. The data used includes complete experimental records, stress and strain contour plots from simulations, and calculation reports. The test results showed that the preparation period was significantly shortened and bamboo consumption was reduced. The improved model demonstrated enhancements in mechanical properties such as strength, stiffness, and stability. Students' skills in quantitative analysis, numerical modeling, technical writing, and hands-on project work have also improve. Students' skills in quantitative analysis, numerical modeling, technical writing, and hands-on project work have also improved across the board. Course evaluation results and competition awards have improved accordingly.

The method proposed in this paper includes a tiered finite element simulation workflow, a curriculum reform framework, and an approach for building a competition resource repository. These methods are universally applicable and can serve as a replicable practical model for guiding structural design competitions and reforming practical courses in civil engineering departments, providing strong support for the cultivation of innovative engineering talent.

Acknowledgments

The authors acknowledge the Guangdong Provincial College Student Structural Design Competition Committee for providing official contest specifications and loading testing facilities. Gratitude is extended to all participating undergraduate teams from 2022 to 2025 for completing bamboo material experiments, physical model fabrication, and finite element calculation work. Technical support from the YJK and Midas Civil software development teams is also sincerely appreciated.

This work was supported by: Ministry of Education Industry–University–Research Collaborative Education Project, "Training for Enhancing Faculty Practical and Teaching Competencies in Digital Design for Intelligent Construction" (230804699215345); Guangdong Provincial Educational Science Planning Project (Special Project for Higher Education), "Research, Platform Development, and Practice of a Civil Engineering Experimental Teaching Model Integrating Scientific Research and Engineering Technology through Virtual–Physical Integration" (2023GXJK682); and the 2023 Innovation and Entrepreneurship Education Curriculum Development Project of Harbin Institute of Technology, Shenzhen, "Structural Model Design and Fabrication—Guidance for the National College Student Structural Design Competition" (COGP1018).

References

[1] Zhang, Y., Chen, J., & Wang, L. (2021). Innovation and practice of civil engineering talent training mode based on discipline competitions. *Journal of Civil Engineering Education*, 38(4), 56–62. (In Chinese)

[2] Liu, W., Chen, Z., & Wang, L. (2020). Research on the cultivation of innovation ability of civil engineering students based on discipline competitions. *Research in Higher Education of Engineering*, 38(2), 78–83. (In Chinese)

[3] Li, Z., Xu, X., & Wu, Y. (2020). Experimental study on mechanical properties of bamboo strips for structural design competitions. *Journal of Bamboo Research*, 39(3), 45–52. (In Chinese)

[4] Chen, M., & Zhao, H. (2021). Tensile and compressive behavior of glued laminated bamboo under different cross-section configurations. *Construction and Building Materials*, 280, 122456. https://doi.org/ 10.1016/j. conbuildmat. 2021.122456.

[5] Ge, J., Ding, J., & Wang, X. (2019). Application of Midas/Civil in bridge structure analysis. *Bridge Construction*, 49(5), 72–77. (In Chinese)

[6] Park, S., & Kim, J. (2022). Finite element analysis of bamboo truss structures under combined vertical and lateral loading. *International Journal of Steel Structures*, 22(2), 415–428. https://doi.org/10.1007/s13369-022-00860-2.

[7] Zhao, M., Zhou, J., & Sun, L. (2023). Seismic performance analysis of bamboo high-rise tower structures based on YJK. *Structural Engineers*, 39(1), 23–30. (In Chinese)

[8] Huang, R., Xu, L., & Wang, T. (2023). Impact resistance simulation of bamboo truss bridges using explicit dynamics in Midas Civil. In *Proceedings of the 2023 International Conference on Structural Dynamics and Civil Engineering* (pp. 234–241). Guangzhou, China.

[9] Chen, S., & Lin, F. (2024). Stability analysis and optimal design of bamboo floating structures based on Midas Civil. *Journal of Ship Mechanics*, 28(6), 845–853. (In Chinese)