

Original Paper

Teaching Reform of Structural Mechanics Course in Applied Universities under the Background of Engineering Education

Accreditation

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Abstract

Engineering education accreditation takes “student-centered, output-oriented, continuous improvement” as the core orientation, and puts forward clear ability requirements for the training of engineering professionals in applied universities. As the core professional basic course of civil engineering, intelligent construction and other majors, structural mechanics is the key carrier to connect basic mechanics and engineering practice. Its teaching quality directly affects the training effect of students’ engineering literacy and professional ability. In view of the problems existing in the course of structural mechanics in applied colleges and universities, such as abstract and difficult knowledge, disconnection between theory and practice, insufficient motivation of students’ active learning, and single assessment method, combined with the certification standards of engineering education and the orientation of applied colleges and universities, from the four dimensions of teaching content optimization, teaching mode remodeling, teaching method improvement and assessment method reform, this paper puts forward targeted teaching reform strategies, and constructs a teaching system of “integrating theory with practice, paying equal attention to knowledge and ability, and giving consideration to process and result,” aiming at improving the teaching quality of the course and students’ engineering practice ability. To cultivate high-quality applied engineering and technical talents in line with industry needs and certification standards.

Keywords

Engineering education accreditation, applied universities, structural mechanics, teaching reform, engineering practice ability

Engineering education certification is an important measure for China's higher engineering education to achieve international integration and improve the quality of personnel training. Its core is student-centered, training goal-oriented, insisting on continuous improvement (Li, Z. Y., 2014, pp. 9-16), emphasizing the cultivation of students' practical ability and innovative thinking to solve complex engineering problems and adapt to the development of the industry. As the core professional basic course of engineering specialty in applied colleges and universities, structural mechanics covers the core contents of statically determinate structure analysis, statically indeterminate structure calculation, structural displacement and dynamic analysis. It is an important foundation for students to follow up the study of structural design, construction technology and other professional courses. It is also a key link to cultivate students' engineering thinking and practical ability.

At present, there are many problems in the teaching of structural mechanics in application-oriented universities that are not compatible with the requirements of engineering education certification, which are highlighted by the disconnection between theoretical teaching and engineering practice, weak practical teaching links, and insufficient students' learning initiative. As a result, the teaching quality of the course is difficult to meet the needs of applied talents training. Therefore, under the background of engineering education professional certification, we should adhere to education reform and innovation, constantly innovate education and teaching methods, and introduce the modern education concept based on results-oriented into the curriculum teaching system (Sun, N., 2016, pp. 29-34), so as to make up for the shortcomings of the current teaching methods, conform to the requirements of social development for applied talents, and explore the appropriate talent training mode.

1. The Teaching Status and Existing Problems of Structural Mechanics Course in Application-Oriented Universities

1.1 Knowledge Is Abstract and Difficult To Understand, and Students Are Not Interested In Learning

The course of structural mechanics is highly theoretical and logical, including a large number of abstract concepts, complex mathematical derivation and mechanical analysis methods. The knowledge points are closely related and the system is rigorous. The mathematical foundation and mechanical thinking of applied college students are relatively weak. In the face of abstract mechanical models, tedious formula derivation and changeable structural types, it is easy to have a fear of difficulties and it is difficult to quickly understand the connotation of knowledge and application logic. At the same time, the course teaching is mainly based on theoretical knowledge infusion, which is not closely integrated with the engineering practice in the fields of civil engineering and intelligent construction. It is difficult for students to perceive the practical value of the course, which leads to low learning enthusiasm and insufficient learning motivation, and it is difficult to actively participate in the process of knowledge inquiry.

1.2 Theory and Practice Are Disjointed, and the Cultivation of Practical Innovation Ability Is Weak

Influenced by the traditional teaching mode, the teaching of structural mechanics in applied colleges and universities generally has the tendency of “emphasizing theory and neglecting practice”. The teaching focuses on the explanation of theoretical knowledge and the derivation of formulas, and the emphasis on practical teaching and the cultivation of innovative ability is insufficient. The setting of practical teaching links is relatively simple, and most of them are based on classroom examples and after-school exercises. There is a lack of targeted engineering practice projects, numerical simulation training and hands-on operation links, which makes it difficult for students to combine theoretical knowledge with engineering practice, and the engineering practice ability cannot be effectively improved. In addition, there is a lack of guidance for students’ innovative thinking in the teaching process. The course content and teaching methods are relatively solidified, and students are not fully encouraged to explore multivariate analysis ideas and solutions. There is a clear gap between the cultivation of students’ innovative consciousness and innovation ability and the requirements of engineering education certification.

1.3 Students Lack Active Learning, and Deep Learning Is Difficult To Achieve

Application-oriented college students are mostly employment-oriented and pay more attention to the practicability of professional skills. However, the theoretical characteristics of structural mechanics course make it difficult to quickly show their learning results, resulting in students’ lack of internal driving force for active learning. In the process of teaching, students are mostly in a state of passive acceptance of knowledge, lack of awareness of active thinking and active inquiry, satisfied with mastering the basic knowledge points of textbooks and conventional problem-solving methods, unwilling to delve into complex mechanical problems, and do not pay attention to the integration and flexible use of knowledge. At the same time, the lack of effective learning guidance and incentive mechanism in the course teaching fails to fully mobilize students’ learning initiative, which makes it difficult for students to carry out deep learning and form a comprehensive ability to solve complex engineering problems, which is not consistent with the core concept of “student-centered” in engineering education certification.

1.4 The Assessment Method Is Single, and the Process Evaluation Is Missing

Even though various colleges and universities have been gradually reducing the proportion of final exam scores to final scores, the proportion of final exam scores is still large, and the usual scores are mainly based on the completion of homework and classroom attendance, and the assessment method is relatively simple. This evaluation model focuses too much on learning results and ignores the performance of students in the learning process, such as active thinking, group cooperation, practical operation, and innovative attempts. It cannot fully and objectively reflect the students’ learning status and comprehensive ability level. At the same time, the assessment content focuses more on theoretical knowledge and problem-solving skills, and lacks the cultivation of students’ engineering modeling and

practical ability (Chen, L. L., Li, J. Q., Gu, C. J. et al., 2024, pp. 76-83). As a result, students fall into the misunderstanding of “exam-oriented preparation” and ignore the cultivation of comprehensive ability, which is inconsistent with the requirements of “comprehensive evaluation and process evaluation” of engineering education certification.

2. The Teaching Reform Ideas and Measures of Structural Mechanics Course under the Guidance of Engineering Education Certification

2.1 Optimize the Teaching Content and Realize the Deep Integration of Theory and Practice

Combined with the requirements of engineering education certification and the training objectives of applied talents, the principle of “theory foundation, practice empowerment, innovation and intelligence” is strictly followed to systematically optimize the course content, abandon the redundancy theory, strengthen the practice orientation, and ensure that the content can be implemented and easy to implement.

Abandon the complicated, difficult and old teaching content, avoid letting students fall into the boring and difficult mathematical formula derivation teaching content (Xie, D. M., 2024, pp. 43-46), and pay attention to the practical application of teaching content. The derivation of complex theoretical formulas such as the internal force calculation formula of the three-hinged arch, the displacement calculation formula of the statically determinate structure, and the displacement calculation formula of the graph multiplication involved in the teaching process can only retain the core logic, simplify the derivation steps, and focus on guiding students to understand the practical application scenarios of the principle. In the course of the lecture, one typical engineering case is selected for discussion in each class. For example, the internal force analysis of arch structure is combined with Zhaozhou Bridge, the internal force analysis of truss structure is combined with steel roof truss, and the internal force analysis of frame structure is combined with the teaching building of frame structure, so that students can intuitively feel the practical value of knowledge and stimulate their initiative in learning.

Strengthen practical teaching and connect job requirements. Through the finite element modeling analysis, the actual engineering structure project case is applied in the teaching (Zeng, Y. Q., Wang, G. H., Li, B. et al., 2023, pp. 168-170). Two easy-to-use engineering numerical simulation softwares, PKPM and Midas, are introduced. Four hours of practical teaching are arranged every semester. The software modeling, parameter setting, force simulation and result analysis are explained step by step. Students are required to complete the modeling and force analysis of a simple frame structure and submit the practical operation report. Two basic practical projects are added to analyze and check the internal force of simply supported beams and design small frame structures. The project requirements, completion time limit and scoring criteria are clarified, so that students can use theoretical knowledge to solve practical problems in practice and improve their practical ability.

Update the teaching content, keep up with the industry trend. Combined with the industrial application status of assembled concrete frame and light steel structure factory building, at least 2-3 new structural cases are taught every semester, and the latest revised contents of norms and standards are integrated. The outdated structural form explanation is deleted to ensure that the teaching content is synchronized with the needs of the industry position and improve the students' post adaptation ability.

2.2 Reshaping the Teaching Mode, Highlighting the Dominant Position of Students

Breaking the traditional one-way indoctrination mode of "teachers speak and students listen", based on "student-centered", construct an interactive and inquiry-based teaching mode that can be implemented, effectively stimulate students' learning initiative, and take into account teaching efficiency and effect.

Carry out the "case teaching + project-driven" mode and strengthen the ability training. Each chapter takes a real engineering case as the starting point. For example, when explaining the statically indeterminate structure, taking the local multi-storey residential building frame structure as a case, it puts forward practical problems such as "how to calculate the internal force of the frame beam and how to ensure the structural stability", and guides the students to discuss in groups. The core knowledge points of the course are decomposed into small projects throughout the semester, and the division of labor between groups is clarified. The specific division of labor tasks include modeling, calculation, analysis, and reporting. Each group is required to submit a project progress report once a month, and teachers are required to provide regular guidance. In the course of the lecture, the case analysis of engineering accidents is added, such as the collapse accident of the portal frame steel structure plant. Through in-depth analysis of the causes of the accident and the lessons of responsibility, students can shape the correct engineering professional ethics and values (Chen, F. J., & Zhang, J., 2025, pp. 152-160).

Build an "online + offline" hybrid teaching mode to improve teaching effectiveness. Relying on Superstar Learning to build online courses, upload courseware, 10-15 minutes of knowledge point micro-courses, and after-school exercises, students are required to complete basic knowledge point learning before class, and the online punching rate is included in the usual results; the offline classroom focuses on explaining key and difficult points, commenting on cases, and guiding practical operations. Each class is reserved for 10 minutes of group discussion time to solve the problem of low participation of students in traditional teaching and realize online and offline organic integration.

Deepen school-enterprise cooperation, through participation in engineering practice, to achieve accurate docking of classroom teaching and job requirements (Gan, Z. M., 2025, pp. 30-32). Each semester, 2-3 front-line engineering and technical personnel from enterprises are invited to the campus to explain the structural mechanics problems and solutions on the project site in combination with their own work experience. Organize students to practice in local construction enterprises and construction sites once, observe the actual engineering structure construction, and participate in simple internal force analysis auxiliary work.

2.3 Improve Teaching Methods and Enhance the Effectiveness of Teaching Implementation

Combined with the characteristics of structural mechanics with strong abstraction, combined with the cognitive law of applied students, the teaching method of simple and easy operation and landing is adopted to strengthen the pertinence of teaching and cultivate students' logical thinking and practical ability.

Use heuristic teaching to stimulate interest in inquiry. When explaining knowledge points, students are guided to think through progressive questions. For example, when explaining statically indeterminate structures, what is the difference between the force of statically indeterminate structures and statically indeterminate structures? What structures in life are statically indeterminate structures? By asking questions, students are guided to explore solutions independently and avoid mechanical memory.

Promote group cooperative learning and enhance collaboration capabilities. The students were divided into 4-5 groups, and one group leader was selected in each group. The division of labor and cooperation were carried out around case analysis and practical projects. Each group was required to complete a classroom report. The teacher scored according to the content of the report and the division of labor, so as to realize the training goal of students' active participation, efficient cooperation and improvement of communication and cooperation ability.

Using visual teaching to solve abstract problems. Using PPT animation and simple mechanical model, such as simply supported beam and frame structure model, the stress process and displacement change of the structure are presented intuitively. For example, the bending deformation and internal force distribution of the beam are demonstrated by animation, so that students can quickly understand complex knowledge points and reduce the difficulty of learning. Each lesson is set aside for 5 minutes, so that students can observe the model and feel the stress characteristics of the structure by hands.

2.4 Reform Assessment Methods and Improve the Process Evaluation System

Following the principle of "comprehensive evaluation, process evaluation and continuous improvement" of engineering education certification, we break the single final examination mode, construct an operable and process-oriented diversified assessment system, comprehensively reflect students' comprehensive ability, and promote continuous improvement of teaching.

Adjust the assessment weight and strengthen the process evaluation. It is clear that the proportion of final exam scores is not more than 50%, and the usual scores are refined into five aspects: classroom performance, specific assessment indicators for attendance, active speech, questions, etc.; the quality of the work is completed, which is required to be submitted on time, and the performance is evaluated according to the answer of the work. Group cooperation is embodied in the division of labor and the participation of group members. The final score is composed of three parts: teacher evaluation, inter-group mutual evaluation and intra-group mutual evaluation. Practice project results, according to the actual operation report, project report for performance evaluation; the online learning situation was evaluated according to the number of punches and the completion of learning tasks. Each assessment

content has clear scoring criteria to ensure fair and equitable evaluation.

Enrich the assessment content and focus on comprehensive ability. The assessment not only covers theoretical knowledge and problem-solving ability, but also pays more attention to practical ability and professional quality assessment, such as practical project assessment focuses on evaluating software operation and report writing ability, group report assessment evaluation expression and communication and collaboration ability ; in the final examination, a project case analysis question is added to examine students' ability to use knowledge to solve practical problems, which is in line with the output-oriented requirements.

Improve the feedback mechanism to achieve continuous improvement. After each assessment, the results and comments are fed back to the students within 3 working days, pointing out the shortcomings and giving suggestions for improvement. At the middle and end of each semester, a student questionnaire was conducted to collect teaching opinions, adjust teaching content and teaching methods, form a closed loop of teaching → evaluation → feedback → improvement, and implement the concept of continuous improvement.

3. Conclusion

Based on the engineering education certification, combined with the orientation of applied colleges and universities, this paper puts forward targeted reform measures from four aspects: teaching content, teaching mode, teaching method and assessment method, and constructs a teaching system of “integration of theory and practice, equal emphasis on knowledge and ability, and consideration of process and result”. The teaching reform is a process of continuous exploration and continuous improvement. In the follow-up, combined with the development needs of the industry and the cognitive characteristics of students, the teaching content will be further optimized, the teaching methods will be innovated, the assessment system will be improved, the school-enterprise cooperation will be deepened, the practical teaching will be strengthened, the teaching quality of structural mechanics will be effectively improved, the students' engineering practice ability, innovative thinking and ability to solve complex engineering problems will be cultivated, and more high-quality applied engineering and technical talents will be transported for China's engineering construction.

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