Exploration on Teaching Method Improvement in the Course of Design Principle of Steel Structure

Qiang Li, Jianghong Mao, Jun Zhang, Weijie Fan and Yinhui Wang
School of Civil Engineering and Architecture, NingboTech University, Ningbo, China
Email: liqiang@nit.zju.edu.cn

Abstract. The course “design principle of steel structure” is one of the main professional courses in civil engineering, which has the characteristics of many contents, strong theory and high requirement of innovative design ability. Based on the analysis of the present situation of the teaching of the steel structure course in the college, this paper puts forward the existing teaching problems and probes into the concrete methods of the innovation and reform of the steel structure course, which is of great practical significance to improve the teaching effect and the education quality.

1. Introduction
The steel structure system has the comprehensive advantages of large bearing capacity, light weight, easy installation, good seismic performance and recycling. With the structural adjustment of products in the field of construction engineering in our country, steel structure has attracted the attention of the industry because of its own advantages. And it has been reasonably and rapidly applied in many projects, and our country also attaches great importance to the application of steel structure in policy. The construction of a series of super-high and super-large steel structures such as Wanzhou Yangtze River Bridge, Shanghai Jinmao Building, the main building of the new site of CCTV and the Bird's Nest all represent the advanced development level of steel structure in our country [1]. However, due to the late establishment of China's industrial system, there is still a huge space for the development of steel structure, so there is an urgent need to train a number of high-quality steel structure talents with equal emphasis on theory and practice. “Steel structure Design principle” is a very important professional course for civil engineering majors, and it is also an important theoretical and practical source for road and bridge students to understand the working principle of steel structure and engage in steel structure design and construction. However, because of the wide range of contents of this course, the cross-discipline phenomenon of knowledge points is obvious, it is difficult, and the class hours are less. Many undergraduates do not learn thoroughly and forget after learning. How to make students better grasp the principle of steel structure design and apply it in the future work or scientific research process is an important problem for teachers who are responsible for the teaching task of steel structure.

2. Characteristics of Steel Structure Course

2.1. Contents with Interdisciplinary Subjects
The course “design principle of steel structure” has many contents and involves many types of engineering structures, including both light structures and heavy industrial factory buildings. It also includes long-span spatial structures, high-rise buildings, removable mobile structures and reinforced...
concrete structures. The design theory includes the selection of steel, structural connection, structural stability and strength analysis. It also involves the analysis of many codes, codes and engineering examples, from the selection of structures, to the model simplification of structures, to the calculation of strength, stability and deformation of structures, as well as the calculation of welds and bolts of structural connections. It contains knowledge related to civil engineering materials, material mechanics, structural mechanics, elastoplastic mechanics and reinforced concrete design principles and other disciplines, so the course is quite difficult. For undergraduates, it is really difficult to learn well by relying on a single classroom teaching [2].

2.2. Theoretical and Abstract Course
The design principle of steel structure can be divided into three parts: material, construction and connection, and each part of knowledge has a strong theoretical background. The selection of steel structure materials needs to fully consider the mechanical properties, failure forms, classification and influence factors of steel properties. The construction part is an important and difficult part of the whole steel structure curriculum theory, including the calculation of the strength, stiffness and stability of many kinds of load-bearing members, including axial load-bearing members, bending members, tension-bending members and compression-bending members. The related theory of material mechanics is extremely demanding. The construction connection mainly includes two connection modes: weld and bolt, but it involves structural design calculation and strength checking calculation of weld, and there are many types, which deepens the connection theory [3]. Therefore, the steel structure design principle in the strong engineering practice background also has a strong theoretical, more abstract, a single classroom explanation is not conducive to the understanding of students.

2.3. High Demand for Students’ Innovative Design Ability
Having independent steel structure design ability is one of the teaching purposes of the course “design principle of steel structure”, while innovative design is a higher-level requirement of the course. Almost all civil engineering cannot be separated from the design and use of steel structure. On the one hand, good steel structure design can greatly improve the engineering quality, on the other hand, it can also reduce the engineering cost. There are many types and a wide range of cross-disciplines. Therefore, it is very important to pay attention to the cultivation of students’ structural innovative design ability in the course. On the one hand, students are required to choose steel reasonably according to the actual needs of the project, to determine the type of structural system and connection mode, on the other hand, they also need to be able to carry out structural strength calculation, stability and seismic analysis.

3. Analysis on the Present Situation of Steel Structure Course Teaching in School
The teaching purpose of the course “design principle of steel structure” is to enable students to master the basic theories and design methods of steel structures, to check the strength and stability of simple steel structure systems, and to learn the connection principles and connection methods of steel structures. Simple steel structure design can be carried out. Zhejiang University Ningbo Institute of Technology has been adhering to this teaching goal in steel structure teaching for many years, but it has to admit that there are still many problems in the process of curriculum design and teaching. In view of the current situation of the teaching of steel structure course in school, the following analysis is carried out:

3.1. Teaching Methods: Traditional and Lack of Innovation
Since the steel structure course was set up in the school, the traditional blackboard writing teaching mode has been used in the classroom. The teachers teach on the blackboard on the podium and the students listen monotonously below. On the one hand, due to the characteristics of many contents and strong theories in the steel structure course, this boring “instillation” teaching method is very difficult to arouse students’ interest in study and research, on the other hand, because the steel structure is
closely combined with engineering practice, some important knowledge is difficult to teach clearly to the students only by abstract oral explanation, and many complex engineering examples are not easy to show to the students through the blackboard.

3.2. Teaching Contents: Complicated and Lack of Key Points
There are many contents of the steel structure course, and most teachers explain it step by step in the process of teaching, trying to be detailed. It often appears that teachers speed up in a certain part of the course in order to catch up with the schedule, covering up the key points and difficulties. Each course should have different key requirements for students of different majors, and the course should be a little more detailed, so as to help students to better grasp the content of the course.

3.3. Teaching Process: Lack of Pertinence
Civil engineering is a large major with many students in many colleges and universities. In the teaching environment of “batch production” in large classes, the curriculum level of students is uneven and graded seriously, coupled with the classroom teaching method of “instillation”. As a result, many students with learning difficulties are not taken care of in the classroom and do not understand, until they are resistant and weary of learning. This kind of teaching method with low pertinence leads to that only a small number of students can achieve the teaching goal, so it is difficult to improve the teaching quality effectively.

3.4. Teaching Time: Less; Teaching Effect: not Obvious
In the case of courses with many contents, miscellaneous knowledge and deep theory, the steel structure class hours arranged by the school are only 32 class hours, with an average of 2 class hours every 1 week, which makes a lot of difficult knowledge cannot be explained in detail. It is also impossible to enumerate too many important engineering examples in class, which greatly increases the difficulty of teaching, and many teachers cannot pay attention to the quality of teaching while paying attention to the progress of the course, which cannot achieve good teaching results [4].

4. Suggestions on the Innovation and Reform of Steel Structure Course
As mentioned earlier, the steel structure course has the characteristics of many contents, strong theory and high requirements for innovative design ability, but there are many problems in the process of teaching, such as traditional teaching methods, lack of pertinence, less class hours and so on. It makes students generally feel that it is difficult to learn. If teachers want to achieve the teaching goal and ensure the teaching quality in less class hours, there is an urgent need to carry out a series of innovative reforms in the curriculum, strengthen the teaching content, optimize the teaching structure and improve the teaching methods. Pay attention to the cultivation of students’ practical ability and innovative ability, fully combined with the school’s application of innovative talent education concept to put forward the specific methods of curriculum reform.

4.1. Improve Classroom Teaching Methods
The traditional single classroom blackboard writing teaching method is difficult to meet the needs of quality education at the present stage, and it is also difficult to achieve the teaching requirements and purpose of the course. This passive teaching method has eroded the students’ creativity and enthusiasm to a great extent, and the classroom efficiency is low. The purpose of teaching reform is to transform students from passive learning to active and conscious learning, which requires student-oriented teaching methods to improve students’ interest in the classroom and really let them participate in the classroom, cultivate their ability to analyze and solve problems independently [5].

The teaching method of the combination of multimedia coursework and blackboard writing is used. Multimedia coursework has the advantages of intuition, vividness and large amount of information. In class, with multimedia as the carrier, many engineering examples of steel structure are shown to students in the form of pictures or animation, so as to stimulate students’ interest in learning and desire.
to explore. Let them feel that the theoretical knowledge we have learned today will be what we may encounter when we go to work tomorrow, and realize the practicability of the course. From “want me to learn” to “I want to learn” [6]. And through multimedia to visualize a lot of knowledge content, for example, when explaining bolted connection, animation can be used to show students the connection mode and connection steps under different structural conditions, such as on-site, clear and considerable. However, multimedia accelerates the speed of lectures, and teachers need to deduce and explain many important theoretical formulas on the spot, which requires teachers to fully combine blackboard writing, on the one hand, write down the summary of key knowledge of each course on the blackboard, on the other hand, carry out important formula derivation, and flexibly combine blackboard writing with multimedia to improve the teaching effect of the classroom.

Strengthen the interaction with students in class. Teacher-student interaction is a good way to digest classroom knowledge. At the end of each class, about 10 minutes are set aside for students to ask questions, and teachers can answer students’ simple questions on the spot. Teachers can record more complex problems and communicate through Wechat communication group after class. After the students have finished asking questions, the teacher should also ask a few questions about the classroom content for everyone to discuss and communicate before answering. Students with good performance can get extra points in class and join the final grade evaluation, which not only consolidates the classroom knowledge, but also increases the students’ enthusiasm for learning.

Attach importance to the analysis of engineering cases and extend the explanation of knowledge points. The engineering case matched with the theory is an important part of the course explanation, and the case analysis can greatly enhance the students’ interest in learning. It plays a vital role in enhancing students’ understanding of curriculum concepts, mastery of theory and the cultivation of the ability to solve practical engineering problems. The engineering cases quoted in the classroom can be divided into classroom guiding cases, classroom discussion cases and after-class thinking cases. These engineering cases are classified throughout the teaching classroom, which increases the interest of the classroom. At the same time, it also promotes the improvement of students’ engineering practice ability [7]. In addition, because the textbook content has certain limitations, a lot of new professional knowledge cannot be effectively updated in the textbook, so the content must be extended appropriately in the course of lectures. For example, when explaining some norms and procedures, we can compare with some foreign corresponding norms, which can not only enrich the course content, but also arouse students’ interest in learning.

4.2. Strengthen on-the-Spot Practice Teaching
Practical teaching is a weak link in higher education in our country, especially in higher engineering education. In the process of professional teaching, many colleges and universities attach importance to theory rather than practice, and the steel structure course itself has a strong engineering practice background. It is difficult for students to really learn thoroughly without coming out of the classroom. According to the progress of the course, students should be arranged to visit the real objects on the construction site, so that students can really see the application of multi-story steel structure and the distribution of different bolts in different parts of the steel structure system. And put this kind of on-site practical learning into the curriculum design, first through classroom teaching, and then visit the site, and finally do-it-yourself design and production to improve students’ learning effect and creative ability.

4.3. Implement the Curriculum Driven by Scientific Research
Under the background of the implementation of the national innovation-driven development strategy, scientific research ability has increasingly become an important criterion for evaluating the comprehensive quality of contemporary undergraduate students. According to students’ personal learning interests, a group of students with strong learning and research interests in steel structure are selected to participate in relevant scientific research activities, and a great innovation competition group is set up under the guidance of teachers to carry out innovative design of steel structure works.
At the same time, lead students with strong scientific research ideas to do experiments, write papers, write patents, exercise the ability of scientific research and innovation, and lay a good foundation for their future work and in-depth study.

4.4. Increase the Second Class of Software Learning
With the popularization and application of computer and network in engineering, many professional courses have higher and higher requirements for the use of related software. There are many kinds of steel structure design software in engineering, such as 3D3S, PKPM, Xsteel and so on. In order to better meet the teaching requirements, students should be encouraged to learn more simple use of steel structure design software after class and arrange corresponding homework to be completed through the software [8]. CAD is an important learning software for civil engineering majors, and schools have also set up special courses, which can continue to strengthen the study of CAD drawing software while offering steel structure courses, and arrange appropriate computer courses, so that students can skillfully master the three-dimensional structure modeling operation of CAD, and lay a foundation for their graduation design or other modeling software.

4.5. Improve the Mode of Final Examination
Examination is an important part of teaching work, which is not only reflected in the detection of students’ course results, but also can comprehensively reflect the teaching situation of each link in the course. In order to improve the quality of education and cultivate students’ innovative ability, it is necessary to establish a final evaluation method for each course, which can not only truly detect the comprehensive level of students, but also contribute to students’ self-improvement [9]. According to the new teaching contents and methods discussed, the final examination of the steel structure course should be integrated into four parts: the paper score, the usual score, the curriculum design score and the extracurricular development score, and then convert into the final grade according to the proportion of 50%, 20%, 20% and 10% respectively. The examination paper mainly examines the related concepts, theories and calculations of the steel structure course, while the course design examines the students’ ability of engineering case analysis and simple structural design, which is carried out before the final exam. The usual scores mainly refer to the students' performance of answering questions, attendance and homework completion in the classroom, and the corresponding scores are given by the teachers according to the daily teaching records. The extracurricular development scores should refer to the relevant competitions that students participate in during the study of steel structure courses, as well as the practice, experimental reports and paper writing, and the corresponding scores are also given by the teachers according to the extracurricular development materials handed in by the students at the end of the period.

5. Conclusion
The course “design principle of steel structure” has the characteristics of many contents, strong theory and high requirements for innovative design ability. At the same time, it also has a strong engineering practice background, so it is a professional course that is not easy to master. Combined with these characteristics of the course and in view of the problems existing in the teaching of steel structure course at the present stage, a series of teaching innovation and reform measures are put forward in order to improve teaching quality and enhance students’ practical ability and creativity, so that more graduates can meet the quality needs of social talents at the present stage, and train more civil engineering talents with excellent ability of steel structure design and construction for the society.

Acknowledgments
The authors would like to acknowledge the financial supports received from Zhejiang Province Higher Education “13th Five-year” Teaching Reform Research Project (jg20180442) and Zhejiang University Ningbo Institute of Technology Teaching Reform Research Project (NITJG-201721).
References

[1] Li J, Zhao C and Huang B 2007 Design Principle of Steel Structure (People’s Communications Press) (in Chinese).

[2] Ding Y 2004 Design Principle of Steel Structure (Tianjin University Press) (in Chinese).

[3] Wang X and Wan H 2007 Practice and reflection on the teaching of steel structure design Research on Higher Education of Science and Technology (in Chinese).

[4] Chen Z 2010 Exploration and practice in the teaching of steel structure design China Construction Education (05) 57-60 (In Chinese).

[5] Huang L and Xie H 2010 Discussion on the teaching reform of steel structure design principle course Higher Architectural Education (04) 68-70 (in Chinese).

[6] Xue Y 2014 Understanding and practice of steel structure course teaching Fujian Architecture (12) 118-120 (In Chinese).

[7] Wang X 2007 The practice of teaching reform on improving the teaching quality of steel structure course Integrated Technology and Innovation Management (05) 79-84 (in Chinese).

[8] Chen X, Li D and Feng J 2010 Thoughts on the reform of teaching content of steel structure series courses Higher Architectural Education (04) 63-67 (in Chinese).

[9] Yu W, Wang Z and Cai K 2015 Reform and practice of steel structure course design Higher Architectural Education (01) 69-71 (in Chinese).