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A Preliminary Study on the Reform of the Teaching Content of Structural Optimization Design Course

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Abstract: In recent years, with the rapid development of engineering and technology, structural optimization design has played an increasingly important role in modern product design. However, the teaching content and methods of traditional structural optimization design courses are no longer able to meet the needs of the industry. Therefore, reforming the teaching content of structural optimization design courses to meet the needs of the new era for applied talents has become an important part of the teaching curriculum in management universities. This article first analyzes the problems and shortcomings of traditional structural optimization design courses, and then proposes directions and ideas for reforming the teaching content and methods based on the trends and new demands of modern structural optimization design. Finally, the article explores methods for teaching evaluation and course improvement, in order to provide guidance and reference for the teaching reform of structural optimization design courses and promote the better development of university talent for current and future industrial development.

1. Introduction

The course of Structural Optimization Design is a significant major course in the Engineering College. However, the teaching contents and methods of this course have become inadequate to meet the demands of modern engineering design, necessitating reforms. The ever-advancing technological changes brought about by the Industrial Revolution, particularly under the impetus of emerging technologies, have made the task of engineering structural optimization design increasingly complex and challenging. On one hand, the emergence of cutting-edge technologies has led to new breakthroughs in optimization techniques, while the widespread use of computer simulation technology has significantly enhanced the computational capabilities in the field of structural optimization, also providing a means to tackle large-scale optimization problems. On the other hand, more stringent economic and environmental regulations have imposed higher requirements on product functions, performance, cost, weight, energy consumption, and other indicators, posing even more complex challenges to structural optimization design. In this context, this article presents a preliminary exploration of the teaching contents of the Structural Optimization Design course, aiming to put forward a teaching reform plan that aligns with the needs of the new era, in order to cultivate outstanding applied talents who are more in line with industry requirements.

2. Analysis of the Current Teaching Situation of Structural Optimization Design Course

Traditional courses on structural optimization design, to a certain extent, satisfy basic educational needs and provide knowledge transfer. Through these courses, students can learn fundamental concepts, principles, and commonly used methods in structural optimization, thereby mastering basics of structural design and skills. Moreover, some course content includes explanations of classical cases, aiding students in understanding practical applications of structural optimization design and engineering practices. Nevertheless, traditional courses on structural optimization design also have shortcomings and challenges. First of all, course content is relatively narrow, mainly focusing on fundamental theories and methods and lacking case studies and practical aspects related to actual engineering projects. This hinders students from applying theoretical knowledge effectively in real-world application scenarios. Secondly, teaching methods are relatively traditional, mainly consisting of lectures and demonstrations with little interaction and participation. This teaching approach may lead to shallow levels of knowledge absorption and difficulty in cultivating students' self-learning and problem-solving skills. Lastly, some textbooks and teaching resources have long update cycles, failing to keep up with fast-changing engineering practices and technological advancements. In summary, while courses on structural optimization design have positive implications, they also present challenges and flaws. To better adapt to modern engineering design requirements, course content and teaching methods need reformation and innovation, incorporation of more practical cases and applications, more interaction and participation, and updates of textbooks and teaching resources. By continuously improving and perfecting course content and methods, students' learning effectiveness and skill levels can be enhanced, making greater contributions to talent cultivation and professional development in the engineering field [1].

3. Demand Analysis

3.1. Trends and New Needs for Optimized Design of Modern Structures

The trend and new requirements of modern structural optimization design can be mainly reflected in two aspects. Firstly, with the rapid development of advanced computing and simulation technology, the computational power of structural optimization design has significantly improved. More and more engineering can obtain accurate and fast optimization solutions through high-performance computing, which not only improves the efficiency of optimization design, but also provides a foundation for further improving optimization technology. Secondly, the demands of economic globalization and environmental protection have also put forward higher technical and application requirements for structural optimization design. This requires structural optimization design to pay more attention to the practical application of engineering and improve the comprehensive performance of products.

To meet these new trends and requirements, future structural optimization design needs to focus on the following aspects: Firstly, it needs the development and application of optimization methods and algorithms that are more suitable for modern engineering requirements, including nonlinear, multi-strategy optimization algorithms, as well as the application of machine learning and artificial intelligence in structural optimization design. In addition, structural optimization design needs to pay attention to multi-objective optimization research, analyzing, evaluating and weighing optimization solutions under different objectives to achieve comprehensive optimization of product performance and cost, weight, energy consumption and other indicators. Secondly, structural optimization design also needs to strengthen the combination of theory and practice, focusing on the analysis and research of engineering application and practical cases to improve students' practical

abilities and problem-solving skills. Thirdly, it needs to involve knowledge from related interdisciplinary fields, such as mechanics, materials science, computer science, data science, etc., as well as the practical application of CAD, CAE software commonly used in industrial production. Fourthly, it needs to develop digital and intelligent structural optimization design patterns and tools, and optimize the teaching methods of courses through new technological means such as online education platforms. These new technological means can effectively enhance student participation, learning outcomes, and practical abilities, making the courses more innovative and practical.

3.2. Industry Requirements for Applied Talent

The modern engineering industry has raised higher requirements for applied talents. Firstly, the industry demands that applied talents possess the ability to flexibly apply advanced methods and tools for structural optimization design, proficiently master various commonly used algorithms and software for structural optimization, and effectively solve complex problems encountered in practical engineering projects. Secondly, the industry expects applied talents to have higher interdisciplinary literacy, hoping that they have a foundation in mechanics, materials science, computer science, and other related disciplines, and are able to integrate and apply knowledge from different fields. Furthermore, the industry also values the engineering practice capabilities and teamwork abilities of applied talents. They need to have practical experience and skills in engineering applications, be able to effectively communicate and collaborate with other professionals to jointly complete complex engineering projects. Finally, the industry emphasizes the innovation and continuous learning abilities of applied talents. They need to constantly update their knowledge and skills, keep up with the industry's development trends, and actively engage in innovation and improvement to contribute to the development of the engineering industry. In summary, applied talents need to have a foundation in structural optimization design knowledge and skills, possess interdisciplinary knowledge and abilities, have good engineering practice capabilities and teamwork abilities, as well as the spirit of innovation and continuous learning, in order to meet the requirements of the modern engineering industry for applied talents [2].

4. New Direction of Teaching Content Reform of Structural Optimization Design Course

4.1. Introduction of New Optimization Algorithms and Tools

To meet the demands of modern engineering design, it is necessary to reform the teaching content of structural optimization design courses by incorporating new optimization algorithms and tools. On one hand, while traditional structural optimization algorithms have reached a certain level of maturity, the advancement of computational technology has brought forth new algorithms that possess higher computational efficiency and better problem-solving abilities. Therefore, the teaching content should introduce new optimization algorithms, such as evolutionary algorithms, simulated annealing algorithms, and particle swarm optimization algorithms, to help students understand the fundamental principles and applications of these algorithms. This enables students to enhance their comprehension of different types of optimization algorithms, empowering them to effectively tackle various complex engineering problems. On the other hand, with the rapid development of computer science and artificial intelligence, structural optimization design tools have made tremendous progress. Modern structural optimization design software facilitates efficient model building, parametric design, and automated optimization processes, presenting significant advantages in terms of design efficiency and accuracy. Hence, the teaching content should also incorporate these novel tools, enabling students to grasp the basics of operating and applying such software. Through practical exercises and case demonstrations, students can gain a deeper

understanding of the practical application of structural optimization design, improving their engineering practice skills and ability to tackle real-world engineering problems. Additionally, during the process of curriculum reform, it is crucial to integrate the teaching of optimization algorithms and tools with practical engineering cases. By introducing tangible engineering projects, students can apply the learned optimization algorithms and tools to real problems, exploring solutions and performing result analyses and evaluations. This practical teaching approach can better engage students' interest and motivation, nurturing their practical skills and problem-solving abilities.

4.2. Analyze and Practice with the Latest Real-World Cases

In order to enhance the practicality and applicability of the course on structural optimization design, the teaching content needs to be reformed with a focus on integrating and analyzing the latest real-life case studies. On one hand, the teaching content should prioritize engineering practices, incorporating the analysis and exploration of recent practical cases. Through case studies, a deeper understanding of the practical value and optimization effects of structural optimization design in real engineering projects can be obtained. It also allows for in-depth discussions on the challenges and issues encountered in optimization design, cultivating students' abilities to analyze and solve problems. Moreover, the teaching content should closely align with practical engineering applications by incorporating case studies from various industries, enabling students to gain a better understanding of the demands and applications of structural optimization design in different fields. This approach will stimulate students' interest in learning and enhance their comprehension and application of structural optimization design techniques. On the other hand, the teaching content should also emphasize practical hands-on exercises by replicating and practicing with the latest real-life case studies. Through practical exercises, students can experience and witness the process and outcomes of structural optimization design, developing a better understanding of the principles and optimization details of this design approach. Additionally, the teaching content could introduce digitalized and intelligent structural optimization design patterns and tools, optimizing practical exercises through technologies such as online deep learning, enabling students to possess advanced, rapid, and precise computational and practical abilities. In summary, integrating the latest real-life case studies with the teaching content of the structural optimization design course not only enhances students' understanding of the practical applications of this design approach but also stimulates their interest in learning and fosters their innovative spirit. It improves their practical operational and problem-solving abilities. As the engineering industry rapidly advances, this approach of integrating real-life case studies into teaching methods is becoming a trend and necessity. We should integrate the latest real-life case studies to gain a deeper understanding and mastery of structural optimization design techniques, providing optimized solutions for future engineering practice and equipping students with a more practical and advanced knowledge system [3].

4.3. Consideration of Interdisciplinary Pedagogical Content

To meet the evolving demands of the modern engineering field, the curriculum of the Structural Optimization Design course needs to undergo interdisciplinary reform. Traditional Structural Optimization Design courses often focus on knowledge and skills in mechanics and structural aspects. However, contemporary engineering design increasingly emphasizes interdisciplinary integrative abilities and holistic thinking. Therefore, in the reform of the curriculum, it is necessary to incorporate more knowledge and skills related to interdisciplinary aspects into the Structural Optimization Design course. Firstly, the introduction of material science knowledge is crucial. Material selection plays a vital role in optimization design, as the mechanical properties, feasibility,

and cost differences of different materials directly impact structural optimization design. Therefore, the curriculum can introduce knowledge regarding the mechanical characteristics of different materials, performance evaluation methods, and material sustainability. This enables students to consider material selection and application in the process of structural optimization design. Secondly, the integration of computer science content is essential. In modern engineering design, computer science plays a crucial role in simulation and emulation, data processing and analysis, and algorithm design. The curriculum can include the cultivation of programming skills, the application of numerical simulation and emulation methods, and the mastery of data processing and analysis techniques. This equips students with the ability to utilize computer science tools to solve practical problems. It contributes to improving the efficiency and accuracy of structural optimization design while fostering students' digital thinking and data-driven capabilities. Furthermore, consideration can be given to incorporating content related to sustainability and environmental science. With an increased environmental awareness, modern engineering design requires not only optimal performance but also considerations of ecological sustainability and environmental impacts. The curriculum can encompass knowledge on sustainable design principles and evaluation methods, the application of low-carbon materials and energy-saving technologies, and environmental risk assessment. This fosters students' ability to integrate sustainability concepts into structural optimization design.

4.4. Exploring Project-Based Teaching Methods

In order to enhance the teaching effectiveness and practical ability of the Structural Optimization Design course, it is necessary to reform the teaching methods and approaches, and explore a project-based approach. Traditional classroom teaching mainly focuses on knowledge impartation and theoretical explanations, with limited student engagement and practical opportunities. However, Structural Optimization Design is a highly practical discipline, and mere theoretical explanations are insufficient to develop students' practical skills and problem-solving abilities. Therefore, a project-based approach holds significant importance in the Structural Optimization Design course. Firstly, the project-based approach emphasizes the integration of theoretical knowledge with practical projects. By providing students with specific project tasks, they are able to apply their learned knowledge and skills in practice, thereby gaining a better understanding and mastery of the principles and methods of Structural Optimization Design. The teaching content can revolve around actual engineering projects, with the goal of completing the structural optimization design of a specific project. Students can work in groups, participating and taking responsibility for various aspects of the project, from planning and design to optimization. This teaching approach fosters teamwork, problem-solving, and innovative thinking, enabling students to truly grasp the methods and techniques of Structural Optimization Design through practical application. Secondly, the project-based approach encourages students to actively explore and learn. Through self-directed learning and research, students are encouraged to independently seek solutions when facing project challenges. With guidance and supervision from the teacher, they gradually resolve issues and make improvements. This teaching approach stimulates students' interest and initiative in self-directed learning, cultivating their abilities in problem analysis and resolution, as well as fostering independent thinking and research skills. Finally, the project-based approach can also incorporate real-life engineering cases and simulation technologies. By analyzing actual case studies and utilizing simulation software, students are guided to perform structural optimization design. They can employ modern computer-aided design software and simulation tools to simulate analysis and optimize the structure, thereby enhancing their computational and simulation skills, as well as developing practical abilities to solve real-world problems.

4.5. Introduction of Online Learning Platforms and Virtual Labs

TIn order to enhance the effectiveness and learning experience of the Structural Optimization Design course, reforms are required in teaching methods and approaches, such as the introduction of online learning platforms and virtual laboratories. Traditional forms of teaching often require students to physically engage in laboratory work and field studies. However, there are situations where students may be unable to access these sites or participate in classroom activities. In such cases, online learning platforms and virtual laboratories can offer a more convenient mode of learning. An online learning platform can provide students with a wealth of online teaching resources and an interactive learning environment. Through this platform, students can engage in learning anytime and anywhere, allowing for more time to reflect upon and deepen their understanding of the course material. The platform can offer various forms of online teaching resources, such as instructional videos, slide presentations, discussion forums, and group discussions. It can also incorporate intelligent tools for online assessment and learning tracking, enabling better monitoring of students' learning progress and outcomes. Through the online learning platform, students can autonomously choose learning resources and methods, fostering a more flexible and self-directed learning experience. A virtual laboratory serves as an online experimental platform based on computer simulation and virtualization technologies. Through the virtual laboratory, students can simulate and experiment with various engineering problems, thereby improving their mastery of theoretical knowledge and practical skills. The virtual laboratory can provide different virtualized simulation environments, allowing students to observe and comprehend engineering theories related to structural optimization design more intuitively. Students can customize different experimental projects in the virtual laboratory and achieve experimental objectives through simulation, thereby fully understanding and experiencing the principles and methodologies of structural optimization design within the experimental environment [4].

5. Conclusion

Through a preliminary exploration of the reform of teaching content in the course of structural optimization design, this article aims to adapt to the demand for applied talents in the new era and propose some reform directions and ideas. As an important professional course in the College of Engineering, structural optimization design must better adapt to the rapidly changing industrial development. The reform of teaching content in the course of structural optimization design is a complex and crucial task that requires the joint efforts and continuous exploration of all parties involved. It is hoped that the preliminary exploration in this article can provide useful reference for relevant educational professionals and schools, contribute to the reform and optimization of the structural optimization design course, promote the development of the engineering industry to a higher level, and cultivate more outstanding engineering talents with innovative and practical abilities.

References

[1] Komurcu E., et al. Towards composite suspension control arm: Conceptual design, structural analysis, laminate optimization, manufacturing, and experimental testing. Composite Structures 327.(2024)
[2] Wenying Z, Yong Z, Hongwei Z, et al. Structural design and optimization for a 20-cell solid oxide fuel cell stack based on flow uniformity and pressure drop[J].International Journal of Hydrogen Energy, 2023, 48(94):36900-36917.
[3] Zhitong L,Zhaobo C, Xiongbiao C, et al. Design and evaluation of TPMS-inspired 3D-printed scaffolds for bone tissue engineering: Enabling tailored mechanical and mass transport properties[J].Composite Structures, 2024, 327
[4] Pouya M,Mehdi B,Siamak T .Ethnic groups chaos game optimization algorithm for optimal design of steel structures considering seismic risk[J].Engineering Optimization, 2023, 55(11):1886-1904.