

Strategies for Teaching the Reinforced Concrete Structures Course in Engineering Majors

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Abstract: The cultivation of engineering capabilities aims to equip engineering professionals with high-level expertise to meet the demands of society and industry development, thereby enhancing their competitiveness and career potential. This article focuses on engineering capability development, exploring teaching strategies for the Reinforced Concrete Structure course. It aims to provide insights for educators in engineering programs at universities and vocational colleges in China. By doing so, teaching plans that meet the needs of engineering capability development, laying a solid educational foundation for the healthy growth of engineering professionals in the new era, and enhancing their application of knowledge and skills can be developed.

Keywords: Engineering ability; Reinforced Concrete Structure course; Classroom practice; Expert exchange

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1. Introduction

The development of engineering capabilities is crucial for the growth of engineering professionals. On one hand, excellent engineering capabilities aid individuals in understanding and mastering fundamental theories and applying them to solve practical engineering problems effectively. On the other hand, engineering capabilities emphasize the cultivation of practical skills. This allows engineering professionals to operate and practice in real-world environments, enabling them to comprehend and master engineering principles, design, construction, and management procedures. This enhances their abilities in engineering design, analysis, and management while fostering critical thinking and innovation skills during their learning process. Therefore, conducting research on teaching strategies related to engineering capability development in relevant courses is a highly valuable endeavor. It aims to enhance the competitiveness and career potential of engineering professionals.

2. Connotation of engineering ability cultivation

Engineering professionals, as the central force driving the development and innovation in the engineering field,

require the cultivation of engineering capabilities, which is a crucial aspect of engineering education. These capabilities include specialized knowledge, innovation and problem-solving skills, practical and operational abilities, as well as a sense of responsibility and professional ethics.

Firstly, the cultivation of specialized knowledge forms the foundation of engineering capability development. This typically includes mastering fundamental disciplines, basic engineering knowledge, and specialized field expertise. At this level, professionals are required not only to grasp theoretical knowledge but also to undergo training in experimental skills. Secondly, fostering innovation and problem-solving capabilities is essential for engineering professionals. They need to possess strong innovative thinking and problem-solving skills to propose innovative solutions and approaches for challenging engineering projects. This ensures effective handling of various difficulties encountered in engineering design and construction. Thirdly, developing practical and operational skills constitutes the core practical aspect of engineering capability. This usually involves acquiring skills in experimentation, operation, and engineering design. Fourthly, fostering interdisciplinary knowledge is crucial in the current era where engineering projects often span multiple disciplines and fields. Therefore, engineering professionals need to possess interdisciplinary knowledge to address various challenges in practical engineering projects ^[1].

3. Principles of the Reinforced Concrete Structure course

3.1. Practical

The practicality of the reinforced concrete structure course means the applicability of the knowledge and skills of the course in engineering projects. The syllabus should align with real-world engineering problems and emphasize the cultivation of practical and problem-solving skills.

3.2. Forward-looking

The syllabus of the Reinforced Concrete Structure course should also be forward-looking. This means that the course content should be updated regularly and align with the latest development trends. The course should also prepare the students for solving future engineering problems. The content should not only encompass traditional knowledge of reinforced concrete structures but also integrate emerging construction methods, technologies, and materials. This includes information on environmentally friendly and sustainable materials, construction techniques, and other relevant advancements, which should all be incorporated into the teaching curriculum.

3.3. Experiential

The Reinforced Concrete Structure course should also focus on personal experiences. Through practical activities, students can personally engage with and experience the development of knowledge, apply critical thinking, and thereby gain a deeper understanding and mastery of how to use that knowledge. Experiential learning enhances their sense of connection and identification with the knowledge they acquire.

3.4. Diversity of teaching methods

To better impart knowledge and skills during the teaching of reinforced concrete structures, it is important to accommodate individual differences among students. Embracing diverse teaching methods is essential like integrating lectures, demonstrations, hands-on practice, and case studies. Additionally, leveraging information technology tools such as online teaching, flipped classrooms, and artificial intelligence can further stimulate students' interest and motivation to learn. These approaches aim to deepen students' understanding of knowledge and skills effectively.

4. Research on the teaching strategies Reinforced Concrete Structure in relation to engineering capability cultivation

4.1. Strengthening the connection between the knowledge system and practical projects

When designing the curriculum for Reinforced Concrete Structures, teachers should identify the key knowledge points that the course should cover. These include fundamental aspects such as the basic types of reinforcement, their physical and mechanical properties (hardness, strength, ductility, plasticity, etc.), surface characteristics, specifications, weights, and the compatibility between concrete and reinforcement. Subsequently, each major knowledge point should be linked to practical reinforced concrete structure projects.

While teaching the theories, teachers can start by discussing the basic types of reinforcement. They can introduce commonly used types such as prestressed reinforcement, hot-rolled reinforcement, and cold-drawn reinforcement in the fields of building and bridge engineering. Simultaneously, through associated analysis with practical projects, students can observe and identify different types of reinforcement materials used in engineering projects and understand how they are used. When describing the physical and mechanical properties of reinforcing steel, teachers can elaborate on the definition of each property (hardness, strength, ductility, plasticity, etc.), testing methods, and the practical impact of these properties on the overall quality and stability of reinforced concrete structures. After learning the theories, students should engage in related practical project analysis. This involves conducting mechanical performance tests on samples prepared by the instructor during class, observing, and recording experimental data. This process helps them further understand the correlation between these physical and mechanical properties and the performance of reinforced concrete structures.

For example, when teaching about the surface characteristics, specifications, and weight of reinforcement, the teacher can explain the related standards and requirements. During project analysis, students can engage in actual measurement activities. Using their theoretical knowledge, students calculate the specifications and weight of reinforcement. Subsequently, they compare their measured results with the standard requirements, deepening their understanding of the significance of these measurements in real engineering applications.

When explaining the compatibility between concrete and reinforcement, the teacher can discuss how concrete and reinforcement interact and the direct impact of this interaction on structural performance. In the associated practical project analysis phase, instructors can lead students to internship sites. Here, students are required to cut, bend, and tie reinforcement according to project design requirements. They then prepare concrete and fabricate reinforced concrete test specimens, followed by conducting subsequent mechanical performance tests.

The course design described above tightly integrates theoretical knowledge with practical projects, enabling students to better understand and apply the physical and mechanical properties of reinforcement. This approach enhances the practical utility of engineering capability development.

4.2. Strengthening classroom practice

To better integrate theoretical knowledge with practical skills in teaching Reinforced Concrete Structures, in-class practical activities can be emphasized further ^[2]. After covering foundational theories from the textbook, teachers can introduce various hands-on activities. These could involve creating physical models, organizing group competitions, conducting field experiments, and preparing project reports. These diverse activities aim to engage students actively and demonstrate how theoretical concepts apply in real-world scenarios. This approach enhances learning by connecting theory with practical applications in the context of reinforced concrete structures.

In the aspect of creating physical models, teachers can encourage students to construct their own steel reinforcement models corresponding to different concrete structures. After explaining the theoretical knowledge

and requirements of reinforcement performance, teachers can instruct students to simulate basic structures of actual high-rise buildings, bridge structures, and tunnel structures based on these models. This hands-on approach allows students to intuitively understand the practical application of reinforcement and performance control schemes in various concrete structures. As for the group competition strategy, teachers can divide their students into groups and task them on building models. Each group gets to present their models while other classmates get to raise questions and provide feedback. Competition between different groups method effectively enhances students' practical skills, communication skills, and teamwork abilities ^[3]. For field experiments and site inspections, teachers can select construction sites near the school or completed building projects based on regional characteristics. Leading students on-site allows them to closely observe the specific requirements of reinforcement performance in concrete structures, thereby deepening their understanding and application of their knowledge. After each activity, teachers can require each group to submit a comprehensive report. The report should include the process of the activities, observations, personal experiences, and personal reflections related to the course material.

Additionally, teachers can schedule academic seminars during class to discuss specific points of knowledge. After the course, arranging these seminars allows each student to present their insights on the performance of reinforced concrete structures. At this moment, teachers should respond to students' viewpoints and questions effectively, facilitating a deeper understanding of both theoretical concepts and practical applications through interactive learning ^[4].

4.3. Enriching teaching methods

Diverse teaching methods are crucial means to effectively promote students' deep understanding of knowledge and skills, thereby further enhancing their interest in learning. Building upon strategies that integrate theoretical knowledge with practical projects and enhance in-class practical activities, teachers should further diversify teaching methods by integrating technologies that align with the preferences of modern youth and have shown significant results in the field of education ^[5]. For instance, teachers can leverage information technology to create online learning platforms, allowing students to engage in remote learning outside class hours, thus overcoming limitations of time and space. Additionally, integrating artificial intelligence technology into classrooms is also a highly suitable method that matches the preferences and psychological needs of modern youth.

On the one hand, teachers can leverage information technology to establish an integrated online learning platform. This platform aims to provide students with avenues for self-study and knowledge acquisition outside of class hours. When developing the platform, it is essential to incorporate a feedback mechanism tailored for student self-learning. This includes integrating artificial intelligence algorithms that enable students to engage in independent study, review materials, and actively test themselves based on platform feedback. By leveraging these capabilities, students can assess their own knowledge levels and identify areas of weakness in their knowledge structure, thus facilitating targeted learning efforts moving forward ^[6].

On the other hand, teachers can introduce artificial intelligence teaching assistants during the teaching period to provide personalized learning suggestions. These teaching assistants can tailor learning resources and paths based on each student's learning progress. Additionally, virtual reality (VR) and augmented reality (AR) technologies can be utilized to simulate complex reinforced concrete structures and rebar arrangements. This allows students to personally operate in a virtual environment, experiencing the physical and mechanical properties as well as structural characteristics of reinforced concrete structures, thereby enhancing their understanding and memory retention.

Furthermore, teachers can apply big data analytics by collecting and analyzing students' online learning data. This enables them to grasp the learning progress of each student and adjust their lessons accordingly in later stages ^[7].

4.4. Strengthening communication with experts

Facilitating exchanges between students and industry experts helps students gain a deeper understanding of reinforced concrete structures. At the same time, schools can leverage the experience and wisdom of the experts to enhance the quality of the course. Exchanges between experts and students can be carried out in three ways: imparting experience, sharing professional knowledge, and assessing skills.

In terms of imparting experience, schools can have experts share challenging problems encountered in practice and their thought processes in resolving these issues. This approach inspires students to propose innovative solutions and approaches when facing various engineering problems ^[8]. For sharing professional knowledge, schools can invite experts to share practical knowledge and theories beyond the scope of textbooks and guide students' thinking by addressing their questions, thereby deepening students' understanding of professional knowledge. Regarding skills assessment, experts can evaluate the effectiveness of students' solutions, work efficiency, and multidimensional engineering competencies such as teamwork, and provide valuable feedback to help students gain a comprehensive understanding of their engineering capabilities for their future careers.

4.5. Optimization of school-enterprise collaborative graduation internship programs

School-enterprise collaborative graduation internship programs serve as the final preparation for graduates. Optimizing internship projects will further promote the enhancement of engineering capabilities in talents. Teachers should assist students in establishing clear internship objectives. This ensures that students gain a deep practical understanding of reinforced concrete during the internship, including mastering key technologies, understanding potential challenges in actual engineering, and learning how to address problems ^[9]. Subsequently, in the graduation internship project, real engineering projects should be created where students participate in the design, construction, and management of reinforced concrete structures within enterprises. Through involvement in actual projects, students can better understand and master the entire process of construction engineering, as well as the related design and construction processes of reinforced concrete structures.

In addition, the graduation internship project should involve enterprise instructors and invite engineering professionals from relevant fields within the industry. These professionals can assess and provide feedback on students' practical engineering capabilities during their participation in the projects. Through close interaction with students and teachers, both parties gain a deeper understanding of the industry's and enterprises' demands for their engineering capabilities. This feedback loop accelerates the students' further enhancement of their knowledge structure and practical skills ^[10].

5. Conclusion

Engineering capability is a crucial factor for engineering professionals to adapt to industry developments, enhance employability, and increase competitiveness. Using the teaching of the Reinforced Concrete Structures as an example, this paper explores strategies to effectively improve students' engineering capabilities during the teaching process. This paper can be used as a reference to create a curriculum focused on developing these skills. These teaching practices aim to foster and enhance the engineering capabilities of engineering students

and provide them with the tools to solve real-world problems and demonstrate their abilities in future careers and projects.

Disclosure statement

The author declares no conflict of interest.

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