# Teaching Reform and Practice of Mechanical Innovation Design Course Based on Engineering Case Application

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**Abstract. Abstracts.** The objective is to cultivate high-quality engineering talents with an innovative spirit and practical ability, and to improve the professional quality of engineers through the implementation of a mechanical innovation design education programme. This paper analyses the current status of teaching in the mechanical innovation and design course, identifying deficiencies in the course content, case studies and teaching methods. It proposes reforms in these areas, building on the engineering case teaching method and exploring the potential of these reforms for the further development of mechanical innovation and design education.

**Keywords:** mechanical innovation design; engineering case studies; practical ability

## 1 Introduction

The engineering education model espouses the pedagogical approach of 'student-centred and output-oriented'. To more effectively implement this approach, the mechanical innovation design course has been redesigned with the teaching objectives of integrating knowledge, connecting with society, and enhancing the comprehensive quality and ability. This aligns with the demands of science, the economy, and society, as well as the requirements of higher education development.[1] The objective of the course is to integrate the disparate knowledge acquired during the undergraduate phase through the analysis of projects that present a certain degree of difficulty, thereby enhancing the students' capacity to solve authentic problems. In order to cultivate high-quality engineering talents with innovative spirit and practical ability, China's colleges and universities have implemented a teaching reform and practice programme for mechanical innovation design courses. This paper will discuss the aforementioned reform and practice programme, with particular reference to the application of engineering cases.



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## 2 An examination of the present state of mechanical innovation design course instruction

The genesis of the mechanical innovation design course can be traced back to the early 1980s, when China's higher education sector began to gradually recover and reform. In light of the accelerated advancement of science and technology and the mounting demand for highly skilled professionals in society, the focus of higher education has gradually shifted from the mere transfer of traditional knowledge to the nurturing of students' innovative consciousness and practical abilities. In this context, some colleges and universities have initiated the introduction of courses related to mechanical innovation design, with the objective of fostering students' innovative abilities and practical skills in the mechanical field. Currently, the following issues predominantly manifest in the teaching of mechanical innovation design at Chinese colleges and universities.

### 2.1 Mechanical innovation design course lectures are boring, poor learning effect

The Mechanical Innovation Design course represents a significant elective option for those pursuing a degree in mechanical engineering. Its objective is to foster the development of innovative thinking, design capabilities and proficiency in mechanical system innovation. However, despite its intrinsic value, the course frequently encounters challenges in terms of engaging teaching methodologies and effective learning outcomes. This paper will delve into the underlying causes of these shortcomings in the Mechanical Innovation Design course.

Firstly, the teaching mode is single. At present, many colleges and universities' mechanical innovation design courses still employ the traditional teaching mode, which is mainly based on the teacher's lecture. This mode often lacks interactivity, with students passively accepting knowledge. Furthermore, it is challenging to stimulate their learning interest and initiative.[1]

Secondly, the content of the course is not aligned with the latest developments in the field. The rapid advancement of the machinery industry has led to the emergence of new technologies and methodologies. However, the curriculum of some colleges and universities has not kept pace with these changes, failing to integrate the latest technological developments and cutting-edge concepts in a timely manner. This has resulted in a discrepancy between the content of the course and the advancements in the field.

Furthermore, the practical component is often underdeveloped. Practice is the only means of evaluating the veracity of theoretical knowledge. However, in the context of mechanical innovation design, the practical component is frequently either neglected or undermined. Students are deprived of sufficient opportunities to apply theoretical knowledge in a practical setting, leading to a considerable reduction in the efficacy of their learning.

Ultimately, the assessment method is flawed. The predominant assessment approach is based on a final examination, which primarily assesses students' knowledge retention

and comprehension. However, this method fails to adequately evaluate students' innovation and practical abilities. This assessment approach is inadequate for comprehensively reflecting students' learning achievements and ability levels.[2]

### 2.2 Insufficient teaching cases of mechanical innovation design and untimely updating of cases

The subject matter of mechanical innovation design is inherently abstract, and mechanical innovation design problems frequently encompass design concepts and market demand. Consequently, students lacking practical experience in engineering and social practice may encounter difficulties in comprehending the intricacies of mechanical innovation design. Secondly, the engineering mechanical innovation design problems are themselves highly complex. It is challenging to convey the intricacies of these problems in a concise manner within the confines of a teaching framework. While typical cases of engineering can effectively assist students in comprehending and analysing the mechanical innovation design problems inherent to engineering, there is a paucity of existing cases pertinent to the profession within the textbook. Moreover, the incorporation of the latest engineering cases related to the profession into the textbook may prove challenging. Additionally, the majority of cases selected for inclusion in the textbook pertain to negative typical cases. The introduction of positive typical cases could prove beneficial in the teaching of mechanical innovation design.

### 2.3 Poor relevance and lack of specialised teaching materials for mechanical innovation design

Firstly, the content is not sufficiently updated. Some current textbooks may fail to reflect the latest mechanical design theories, techniques and methods in a timely manner. The rapid development of science and technology has resulted in the emergence of new design concepts and tools on a regular basis. Consequently, textbooks must be updated on a regular basis to ensure that they remain current and cutting-edge.

Secondly, there is a paucity of practical cases. The textbook frequently lacks case studies that are grounded in actual engineering, which constrains students' capacity to apply theoretical knowledge in practice. Actual engineering cases can facilitate students' comprehension of design principles and methods, and enhance their ability to address practical challenges.

Furthermore, there is a dearth of interdisciplinary integration. Contemporary mechanical design places a premium on interdisciplinary knowledge integration, yet some textbooks may fall short in adequately addressing the subject matter in related fields such as material science, electronic technology, computer-aided design, and other domains pertinent to mechanical design. The integration of interdisciplinary knowledge fosters a more expansive understanding and enhances students' innovative capabilities and comprehensive quality.

Additionally, there is a dearth of international content. Some textbooks may inadequately address international advanced mechanical design concepts and technical standards. Incorporating international advanced design concepts and technical stand-

ards will facilitate students' comprehension of international dynamics and enhance their international competitiveness.[2]

### 2.4 Weak integration of civics in the curriculum

The mechanical innovation design course places an emphasis on cultivating students' innovative thinking and practical ability. This is in line with the national demand for the construction of a strong manufacturing country and offers significant advantages in the construction of the course's Civics and Politics. Integrating ideological and political elements into the curriculum can facilitate students' comprehension of the pivotal role and mission of their respective disciplines in national development, thereby fostering a sense of professional honour and social responsibility.[3] The introduction of concepts such as 'great power' and 'super project', alongside other pertinent examples of mechanical design, can help students to appreciate the importance of their learning and future work for national advancement, thereby enhancing their motivation to study and fostering a spirit of endeavour.

Although the concepts of OBE and moral education are mutually reinforcing, the pivotal role of course ideology in fostering innovation and entrepreneurship is frequently overlooked in the implementation phase.[4] The mechanical innovation design course has direct contact with society and is directly facing the market. It should utilise its curricular advantages to guide students to gain social acceptance in innovation and entrepreneurship training and to stimulate students' motivation to innovate and entrepreneurial awareness. Some teachers tend to focus excessively on the training of experimental skills and the understanding and mastery of objective laws, neglecting the excavation and integration of civic and political elements.

Consequently, educators may select illustrative examples pertinent to the course content, which may encompass either triumphant instances of innovative design or insights gleaned from unsuccessful endeavors. Through case analysis, students are prompted to contemplate the civic and political elements embedded within these examples, such as patriotism, social responsibility, professional ethics, and so forth. This approach not only enhances students' interest and participation in learning, but also allows them to experience the meaning and value of Civic Education in practice.

## 3 Mechanical innovation design course teaching reform ideas

Mechanical Innovation Design is a course that offers students the opportunity to gain a comprehensive understanding of mechanical design, manufacturing and automation. It is a practical course that combines theory with hands-on experience, and it is typically offered during the sixth semester. The course primarily encompasses modules on creative thinking, TRIZ innovation theory, bionic machinery, mechanism innovation and mechanism combination innovation. The principal objective of this course is to foster the development of innovative design capabilities, comprehensive design abilities and a spirit of teamwork among college students; to reinforce the cultivation of students' practical abilities and engineering practice training, and to enhance students'

capacity to undertake The practical work includes creative thinking, mechanical design and production in response to practical needs. Furthermore, the programme aims to attract and encourage the majority of students to participate enthusiastically in extra-curricular scientific and technological activities, and to create the conditions for outstanding talents to stand out. It is of great importance to reinforce the connection between academic education and the industrial sector, to facilitate the transformation of scientific and technological knowledge into productive resources, to encourage greater participation by younger students in the field of mechanical design and manufacturing, and to enable them to play an active role in China's transition from a manufacturing power to a manufacturing powerhouse.

In order to enhance students' capacity to integrate professional knowledge and simultaneously foster their intellectual agility and ingenuity, it is imperative to implement a comprehensive reformulation of the pedagogical approach to the mechanical innovation design course. This paper will integrate the case teaching method, encompassing four key domains: teaching content innovation, teaching case construction, teaching method reform and teaching effect evaluation. This approach aims to stimulate students' intellectual curiosity and enhance their learning efficacy, ultimately achieving superior educational outcomes.

### 3.1 Innovation in teaching content

The full-time mechanical design and manufacturing and automatic professional mechanical and electronic engineering undergraduate course, which is the sixth semester for mechanical engineering students, is taught by mechanical engineering teachers. The teaching hours are 32, with 2 hours of teaching per week. The textbook used is Mechanical Innovation Design and Application, edited by Liu Shuang and other editors from the Shanghai Jiaotong University Press. In the classroom, teachers employ actual case studies and project practice to illustrate the mechanical innovation design process. They select representative domestic and international success stories to demonstrate the evolution of ideas into tangible products. Through detailed case studies, students gain insight into the entire process, from initial concept to final implementation. The cases presented may include examples from the fields of aerospace, automotive manufacturing, robotics, automation and other areas, with the objective of enabling students to gain an understanding of the practical applications and market value of innovation design. The teaching mode adopted is project-driven, allowing students to work in groups to complete an actual mechanical innovation design project. The project may encompass the entire process, from requirement analysis and conceptual design to detailed design and prototyping, thereby encouraging students to apply their learning and solve real problems in practice.[5]

Upon completion of their undergraduate studies, students who have majored in mechanical design and manufacturing and its automatic exchange are typically employed in roles related to mechanical equipment research and development, manufacturing, after-sales, and other pertinent fields. These roles necessitate a high level of proficiency in mechanical design and the capacity to effectively address engineering challenges. In the lecture, we utilise a case-based teaching approach, whereby the

introduction of actual engineering cases enables students to gain a deeper comprehension of the practical applications of theoretical knowledge. To illustrate, we examine the design of the latest model produced by a prominent automobile manufacturing company, evaluating its innovative features and practical applications. A representative example of a mechanical innovation design should be selected for detailed analysis and group discussion. Students are required to analyse the cases from multiple perspectives, including technology, market and economy, and to propose improvements, in order to cultivate systematic thinking and comprehensive abilities. The project-based learning method allows students to engage in the completion of an actual mechanical innovation design project in a group. The implementation of the project allows students to apply their knowledge from the classroom to practice and enhance their practical abilities and teamwork skills. It is recommended that students be given the opportunity to visit relevant enterprises and research institutions in order to gain first-hand knowledge of the latest mechanical equipment and technology. By communicating with experts from these organisations, students can obtain information that is not available from textbooks and other sources, thus providing a realistic basis for innovative design. Once the project has been completed, students should present their design ideas and implementation process in a results presentation session. Teachers and industry experts will then evaluate the students' work and provide feedback, which will help students to summarise their experience and improve their innovation ability.

### 3.2 Teaching case construction

The establishment of a mechanical innovation design teaching case base provides the foundation for the implementation of case-based teaching, with the quality of cases directly influencing the efficacy of case-based instruction. It is therefore of great importance to construct a case base for the mechanical innovation design course. The construction of the case library for this course is a complex process, which aims to provide students with a rich source of learning resources, stimulate their innovative thinking and enhance their ability to solve practical engineering problems. This is achieved by collecting, organising and presenting a series of representative and innovative mechanical design cases. The following are the key steps in the construction of the cases.[6]

The selected outstanding works should comprise innovative, practical and typical design cases from existing college students' innovative projects and competition award-winning works. In order to ensure comprehensive coverage of all aspects of mechanical design, the cases should encompass the innovative design of the principal scheme, the innovative design of the mechanism, the innovative design of the structural scheme and so forth.

In addition to innovation projects and competition works within the school, consideration can be given to introducing enterprise cooperation projects, cases of leading technologies in the industry as well as advanced design cases in the international arena. This approach has the potential to broaden students' horizons and expose them to a more diverse range of design concepts and technical realisations.[7]

The creation of an online casebook platform is recommended to facilitate students' access to learning materials and enhance their learning experience. This platform should be equipped with functions such as searching, filtering, bookmarking and sharing in order to optimise students' learning efficiency and participation.

The case teaching method is a more effective approach to enhancing students' learning interest in the context of a mechanical innovation design course. The introduction of engineering cases enables students to rapidly comprehend the subject matter and thereby stimulate their interest in learning. For instance, cases can be presented by viewing pertinent videos or introducing pioneering technologies. In the participatory learning session, the focus is on student participation, interaction and feedback. This can be achieved through the utilisation of fine-tuning and white space, solo student learning, group discussion and Q&A, and critique. An engineering case is employed to exemplify the practical application of pedagogical reform.

### 3.3 Reform of teaching methods

The case teaching method is a more effective approach to enhancing students' learning interest in the context of a mechanical innovation design course. The introduction of engineering cases enables students to rapidly comprehend the subject matter and thereby stimulate their interest in learning. For instance, cases can be presented by viewing pertinent videos or introducing pioneering technologies. In the participatory learning session, the focus is on student participation, interaction and feedback. This can be achieved through the utilisation of fine-tuning and white space, solo student learning, group discussion and Q&A, and critique. An engineering case is employed to exemplify the practical application of pedagogical reform.

Prior to the commencement of instruction, it is essential to elucidate the learning objectives of a given programme. This enables students to gain an understanding of the knowledge and skills that they are expected to acquire in order to facilitate effective learning and thinking.

It is recommended that a selection of suitable cases be made, as illustrated in Fig. 1 and Fig. 2 These cases should encompass the essential knowledge points of the course and stimulate students' curiosity and spirit of exploration.

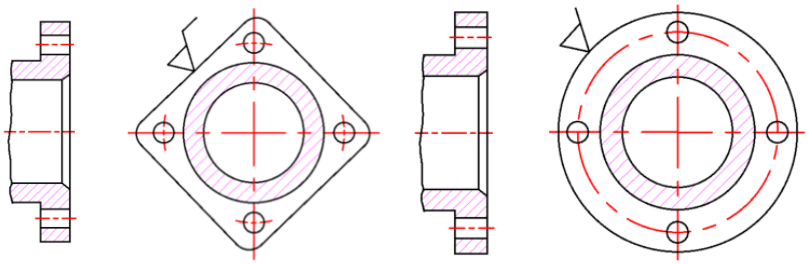
The pre-test serves several purposes. Primarily, it assesses students' mastery of the prerequisite basics. Secondly, it provides a basis for subsequent case studies. Thirdly, it helps teachers understand students' learning status.

The pedagogical approach adopted is that of participatory learning, whereby students are encouraged to engage actively in the analysis of cases. Furthermore, interaction and knowledge sharing among students are promoted through group discussions and individual research.

In order to facilitate students' engagement in meaningful discourse, educators should pose questions at opportune moments to encourage critical thinking, foster the development of a coherent understanding of the subject matter, and cultivate the ability to apply theoretical knowledge to practical problem-solving.[8]

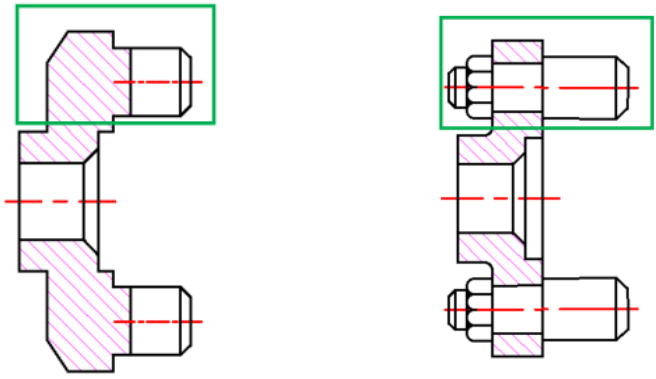
A post-test should be conducted in order to ascertain whether students have acquired an adequate understanding of the material presented in the cases. This should be done

by means of a test or assignment, the results of which will inform any necessary adjustments to the content and methodology of the teaching programme. In addition, students' feedback should be taken into account, as should the completion of assignments.



(a) Less favourable structures (b) Revised structure

**Fig. 1.** Project Case 1



(a) Less favourable structures (b) Revised structure

**Fig. 2.** Project Case 2

## 4 Summary

This study offers a valuable reference point for the cultivation of engineering and technical talent with an innovative spirit and practical ability, through an exploration of the teaching reform and practice of the mechanical innovation design course based on the application of engineering cases. In the future, it will be necessary to explore and improve teaching methods in order to better meet the social demand for engineering and technical talent. Furthermore, this study underscores the pivotal role and function of teachers. In the context of teaching reform and practice, it is imperative that educators continuously update their pedagogical concepts, refine their instructional techniques, and cultivate their teaching abilities and expertise. Furthermore, educators must consider the learning environment and developmental needs of their students, fostering

open communication and offering tailored guidance and assistance in the teaching reform and practice of the mechanical innovation design course based on the application of engineering cases. This approach ensures the effective attainment of the course's teaching objectives and the cultivation of high-quality engineering professionals with an innovative spirit and practical ability.

## Teaching and research Projects

Guangdong University of Science and Technology Higher Education Teaching Reform Programme 2023: Teaching Reform and Practice of Mechanical Innovation Design Course Based on Engineering Case Application (Ratification No.: GKZLGC2023051)

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