Research on the Cultivation of Students' Application Ability in Theoretical Mechanics Courses in Applied Undergraduate Colleges and Universities

Chundong Wu*, Yuting Yan, Hao Wang, Junhui Zhang, Guixiang Tao
Heilongjiang Bayi Agricultural University, Daqing, Heilongjiang, China
**Corresponding Author.*

Abstract: This paper analyzes the possible problems of the current Theoretical Mechanics course on the premise that applied undergraduate colleges and universities attach importance to the need for students to have the ability to solve practical engineering problems, which is mainly reflected in the disconnection between the teaching content and the actual engineering problems, the lack of students' attention to the course, and the inhibition of students' active learning ability by filling in the duck-type indoctrination teaching. To solve this problem, the methodological strategies of optimizing the organization of teaching content and lecture mode, constructing a practical engineering case base, cross-fertilization of disciplines for learning, and establishing a multi-sourcing evaluation method are adopted. It aims to improve students' ability to solve practical problems, and at the same time provides a reference for the reform of the training mode of students' application ability in Theoretical Mechanics courses in applied undergraduate colleges.

Keywords: Theoretical Mechanics; Optimization of Teaching Content; Disciplinary Integration; Case Base; Application Skills

1. Introduction

Applied undergraduate colleges and universities emphasize the cultivation of students' practical application of engineering ability, requiring graduates to be able to adapt to the needs of the workplace to master the required skills. This requires that students not only master theoretical knowledge but also analyze and solve practical problems [1]. Theoretical mechanics is a mechanics course that engineering students are first exposed to during their college years, and it is crucial to their learning. This course can not only help to solve practical engineering problems [2,3] but also needs to be the theoretical foundation for subsequent mechanics courses and specialized courses [4,5].

At present, the theoretical mechanics courses in colleges and universities generally adopt the traditional teaching content and teaching system. The courses mainly focus on conceptual teaching, and the theoretical knowledge is more complicated. Students are not very clear about the application value of the knowledge they have learned, which makes it more difficult to apply the theory to practice in the work. Therefore, for applied undergraduate colleges and universities, the urgent problem to be solved is how to closely integrate theoretical teaching and practical application of engineering [6]. As most colleges and universities have cut down the credit hours of professional foundation courses in recent years, this leads to students being more confused and not understanding when learning. Students generally report that this course is more difficult and it is not clear how it can be applied to practical engineering. Therefore, there is an urgent need to reform the theoretical mechanics course.

To deepen students' understanding of theoretical mechanics courses, this paper adopts methodological strategies such as optimizing the organization of teaching content and lecture mode, constructing a practical case base of engineering, and cross-fertilization of disciplines for learning, aiming at combining theory and practice so that students can better analyze and solve practical problems and lay a solid foundation for subsequent mechanics courses and professional courses.

2. Analysis of the Current Situation

With the popularization of higher education in China, the country is paying more and more attention to the cultivation of application-oriented talents. According to the Outline of the Thirteenth Five-Year Plan for National Economic and Social Development, the Outline sets out an important initiative to promote the transformation of general undergraduate colleges and universities that have the conditions to become application-oriented. This is an emphasis on the cultivation of application-oriented talents. Application-oriented education focuses on cultivating students' practical ability and problem-solving abilities and applying them to actual work and social practice. In contrast, traditional undergraduate education focuses more on the teaching and research of academic theories. Therefore, promoting the transformation of undergraduate colleges and universities into application-oriented ones can better meet the social demand for talent and improve the quality of higher education in China. To realize this transformation, the joint efforts of colleges and universities and all sectors of society are needed to establish a refined management and evaluation mechanism. With the state's devoted support for applied undergraduate education, frontline teachers gradually realize that the standard of measuring students' academic level is no longer limited to paper examination results, but should pay more attention to students' ability to apply what they have learned to solve real-world problems in practice. To further enhance and strengthen the students' ability in solving practical engineering problems, and to promote the reform of engineering teaching of Theoretical Mechanics to educate people. He Fan [7], a professor of the Department of Mechanics in the College of Science of Beijing Architecture University, proposed that applied colleges and universities can improve teaching in many ways according to the problems found in the teaching practice, for example, for Theoretical Mechanics, the focus should be on cultivating the students' ability of logical thinking and combining with the teaching of life examples. In addition, open experiments can be added, which on the one hand cultivates students' ability of practical operation, and on the other hand, increases students' understanding of theoretical contents. Zheng Fei [6] and others from Liaoning University of Science and Technology analyzed the necessity of teaching reform of theoretical mechanics courses for the teaching characteristics of applied undergraduate colleges. The necessity of the teaching reform of the course and its application in teaching practice were analyzed from three aspects, such as the assessment and evaluation system, the content of lectures, and the means of teaching methods. By carrying out the teaching reform of the course, the subjective initiative of the students is significantly improved, they are more and more active in treating learning, and their practical ability and hands-on ability are also improved. Zhang Liyong [1] and others from Anhui University of Science and Technology analyzed the characteristics of the era of contemporary college students and the objective changes that have occurred in the learning environment, and also analyzed the current situation of theoretical mechanics teaching in applied undergraduate colleges and universities, and put forward a new method of teaching engineering, which breaks down the barriers of the connection between the actual engineering problems and the mechanics model, and at the same time analyzed the necessity of the reform to the teaching of theoretical mechanics. They suggest solving engineering practical problems in the classroom using competitions, which improves students' ability to solve practical problems while exerting their enthusiasm. Meanwhile, the teaching content and assessment methods should be optimized to cultivate students' engineering thinking and ability and to improve the teaching effect. Considering the teaching environment and student characteristics of applied undergraduate colleges and universities, Chen Rui [8] and others from the Yellow River Institute of Transportation conducted a study on the teaching reform of the Theoretical Mechanics course, which included redesigning the teaching content, reforming the teaching methods, and reasonably applying Internet resources. Shang Yumei [9] and others from the China University of Petroleum also conducted research on the theoretical mechanics course for applied undergraduate programs.

Foreign courses on theoretical mechanics are

more reasonably designed in terms of teaching content, longer hours, and mathematical tools that can be used to teach theoretical mechanics and analyze and solve related problems. At the same time, the assessment methods are flexible and diversified, which can more effectively reflect the students' usual learning results, in addition, to encouraging group discussion to improve the teamwork consciousness to solve engineering problems. The teaching method is flexible and emphasizes the use of computer software to solve mechanics problems [10]. Meanwhile, it focuses on the coordinated development of students' knowledge, ability, and quality, gives students greater autonomy of choice, and provides a longer time for extracurricular study, this teaching method also provides opportunities for undergraduates to participate in high-level research projects [10]. These experiences are of great significance in the future practice of theory teaching reform.

Therefore, in the development process of theoretical mechanics courses, more and more attention is paid to students' ability to analyze problems and solve practical problems. The purpose of this paper is to improve the training quality of applied undergraduate talents, enhance the practical operation ability, and cultivate high-quality applied compound talents urgently needed by society through the engineering teaching reform strategy of Theoretical Mechanics in applied undergraduate colleges and universities.

3. Existing Problems

Theoretical Mechanics is essential as a foundation course for other mechanics courses and specialized courses such as Mechanical Design and Principles of Mechanics. The class is divided into three parts, including statics, kinematics, and dynamics. Static mechanics mainly explores the simplification of various types of force systems, equivalent calculations, and other issues, focusing on the equilibrium of the object system. Kinematics, on the other hand, focuses on the geometrical properties that result from the motion of an object and the transfer of motion between bodies and does not deal with the causes of motion. Dynamics is a synthesis of statics and kinematics, which not only studies the phenomenon of motion but also explores the causes of motion. At present, there are some problems in the teaching of theoretical mechanics course, this paper takes the theoretical mechanics course as an example and puts forward practical teaching reform suggestions for the problems faced in the teaching reform, such as course content, teaching form, and so on.

3.1 Disconnection between Teaching Content and Actual Engineering Problems

Students show high enthusiasm and interest at the beginning of the theoretical mechanics course, however, with the depth of the course, students' interest gradually wanes, and some students even choose to give up. The theoretical mechanics course is highly theoretical because it is based on the five axioms of statics and relies heavily on Newton's three laws and other classical mechanical theories [11]. Through the methods of logical reasoning and mathematical deduction, the course reveals the theorems, laws, and formulas of the laws of mechanical motion, and establishes a complete and rigorous theoretical system from multiple perspectives, which is the distinctive feature of the theoretical mechanics course [11,12]. However, those students who lack engineering concepts, generally find the abstract nature of theoretical mechanics difficult to comprehend and mistakenly believe that the course is purely theoretical and has little use in their future work [11]. This leads many students to lose their interest in learning theoretical mechanics because they find the course monotonous and boring, difficult to learn, and hard to understand. This not only harms the learning of theoretical mechanics but also makes the subsequent professional courses more difficult to learn.

3.2 Students Do Not Pay Enough Attention to the Course

Theoretical Mechanics is usually taught during the freshman and sophomore years, with courses such as physical mechanics, linear algebra, and calculus as prerequisites. Some students who begin to study Theoretical Mechanics may feel that the course content is repetitive with the mechanics they have studied before, and thus tend to have a contemptuous mindset towards the course. However, with the depth and difficulty of the course, they will find that they can't understand it and then have the idea of giving

up. Theoretical mechanics and physical mechanics have obvious differences in terms of research objects, research problems, application tools, and thinking methods [1], so students should pay great attention to the thinking and master it through careful study, training, and application.

3.3 Fill-in Indoctrination Teaching Inhibits Students' Active Learning Ability

The traditional way of education ignores the student's subjective position, overemphasizes the filler indoctrination, and focuses only on the teacher's teaching while ignoring the students' learning. This approach not only binds students' learning initiative but also is not conducive to cultivating students' independent learning ability. This ability is more crucial than learning knowledge and skills. Therefore, in the teaching process, one should pay more attention to the interaction with students, which can be combined with the study of professionals who will be able to use the students in the subsequent course of the relevant knowledge and mechanics teaching content, in the guidance of the students at the same time, you can encourage students to find and try to solve the problem. This can not only enliven the classroom atmosphere but also stimulate their interest and enthusiasm for learning so that they can use the knowledge they have learned to answer and solve practical engineering problems [6]. In this way, it can not only create a relaxed and lively teaching atmosphere but also enhance students' communication and expression skills, which in turn can achieve the purpose of cultivating students' innovative thinking and realizing engineering quality education.

4. Methodological Strategies

4.1 Optimize the Organization of Teaching Content and Delivery Methods

The current development goal of applied undergraduate colleges and universities is to cultivate high-quality applied innovative talents, so it is necessary to optimize the organization of teaching content [13-15], optimize the teaching lesson plan, organize the knowledge structure, consolidate the foundation of theoretical knowledge, cultivate a new understanding of the theoretical mechanics course for the students, and meticulously delineate the learning process in a gradual and orderly manner, which is more helpful for the students to understand the interconnectedness of knowledge. By enriching the way of teaching, combining the knowledge points of classroom teaching to build a multimedia platform, improving the efficiency of teaching, diversifying assignments, and focusing on students' thinking [16,17], to achieve the requirements of this goal.

The course is highly theoretical and also focuses on engineering practice, so student involvement in the teaching and learning process should be increased. The roles and positions of students and teachers in the teaching and learning process should be diversified. Although the subjective position of students in teaching and learning is emphasized, it should not be over-emphasized, but rather a balance between teachers and students should be sought. It is recommended that diversified teaching sessions be implemented to give full play to the leading role of teachers to ensure the systematic transmission of theoretical knowledge, while fully stimulating students' initiative to meet the needs of different students.

4.2 Constructing a Library of Actual Engineering Cases

Collect practical cases of engineering related to the specialty and establish a case bank. At the same time, these cases are effectively matched with the course chapters to closely integrate theory and practice into classroom teaching. Through practical cases, the abstract teaching content is transformed into concrete examples, to deepen students' understanding of the theoretical mechanics course. Students are divided into groups and assigned the task of practical cases in advance in the teacher-student exchange seminar group. These cases can be related to the content of the course, to give full play to the principle of students' subjective initiative, and take the combination of in-group discussion and teacher guidance for learning. Through continuous refinement and discussion, each group selects a representative to explain to other students in class. Students from other groups can also participate together to communicate and discuss. To cultivate students' learning initiative and interest.

4.3 Cross-fertilization of Disciplines for Learning

Encourage students to participate in mechanics competitions, through the Internet + and other ways to consolidate knowledge and expand strengthening. Advocate students to use CAD, UG, and other drawing software, the actual engineering problems for modeling, and combined with the study of the profession, the application of the corresponding design software for strength preliminary calibration, so that students in a real understanding of the theoretical content at the same time, to master the preliminary design capabilities, and to develop a good analysis of the problem, problem-solving ability.

4.4 Establishment of a Multisource Approach to Evaluation

A comprehensive grading mechanism is established to assess students' regular grades based on the cases they explain, assignments, pre-course preparation, and modeling. This grading mechanism should regularly remind students of the composition of their grades, and individual students who are underperforming should be combined with the group they are in for a collective heart-to-heart talk to realize mutual help and supervision. This can not only stimulate students' sense of collective honor, but also motivate them to participate, and then encourage students to continuously improve themselves.

5. Conclusion

This paper provides a preliminary analysis of the status quo and existing problems in the cultivation of students' application ability to Theoretical Mechanics courses in applied undergraduate colleges and universities at the present stage, and on this basis, puts forward a series of solutions and reform initiatives, which mainly include: optimizing the organization of the teaching content and the teaching method, constructing a practical engineering case base, cross-fertilizing learning of disciplines, and establishing a multisourcing evaluation method, which is aimed at providing references for the reform of the training mode of Theoretical Mechanics course students. Theoretical Mechanics" course students' application ability to cultivate research training mode reform. Although there are improvement measures, they are not implemented in the specific teaching process, and it is necessary to further strengthen the specific implementation in the next research, based on the effect of the implementation of continuous improvement.

Acknowledgments

This article was supported by a grant from the Education and Teaching Research Project of Heilongjiang Bayi Agricultural University (Project No. NDJY2369).

References

[1] Zhang Liyong, Gou Ruibin, Shen Liquan, et al. Analysis of engineering teaching reform of Theoretical Mechanics in applied undergraduate colleges. Journal of Zhejiang Institute of Water Resources and Hydropower, 2020 (4): 86-88.

[2] Wang Yanchao, Wang Xinfeng, Guo Jianfeng, et al. A study on the improvement of teaching ability of young instructors in military schools in the new era-taking theoretical mechanics course as an example. Journal of Higher Education, 2023 (26): 156-159.

[3] Ai Xinying, Liu Liangkun, Pan Zhaodong, et al. Reform and Practice of Teaching Design of Theoretical Mechanics for Civil Engineering Majors Based on OBE Engineering Education Model. University Education, 2022 (9): 61-64.

[4] Yu Yuemin, Liu Baoliang, Zhao Chunxiang, et al. Exploration and Practice of Case Teaching in Basic Mechanics Courses of Universities. Value Engineering, 2013 (23): 225-226.

[5] Hu Xuzao, Wang Yuqin, Chen Yu. Discussion on the teaching of theoretical mechanics course in applied undergraduate colleges. Heilongjiang Education (Theory and Practice), 2019 (06): 71-72.

[6] Zheng Fei, Ji Min. A preliminary study on the teaching reform of theoretical mechanics course for applied undergraduates. China Modern Education Equipment, 2017 (215): 59-60.

[7] He Fan. Discussion on teaching theoretical mechanics in applied colleges and universities. Education Teaching Forum, 2017 (38): 189-190.

[8] Chen Rui, Zhai Zhijin. Exploration of

teaching reform of theoretical mechanics course in applied undergraduate colleges. Mechatronics Education Innovation, 2019 (21): 151-152.

[9] Shang Yumei, He Dongqing, Ma Lian, et al. Teaching Reform and Practice of Theoretical Mechanics Course for Applied Talents. Course Teaching, 2017 (4): 116-117.

[10] Ye Zhiming, Li Junfeng, Wang Shibin, et al. Analysis of Basic Mechanics Course Materials and Teaching System (II)-Analysis of Foreign Theoretical Mechanics Materials and Teaching System. Mechanics and Practice, 2019 (5): 579-587.

[11] Ji Desheng, Li Hongwei. Exploration and Practice of Reform of Teaching Methods of Theoretical Mechanics in Mechanical Specialties of Applied Undergraduate Programs. China Education Technology Equipment, 2019 (13): 95-99.

[12] Huang Ting. On the application of inquiry-based teaching method in mechanics courses. Journal of Guangxi Nation Normal College, 2012 (3): 79-82.

[13] Hua Haiyan, Lin Hua. Optimization of theoretical mechanics course teaching and cultivation of innovative thinking under the background of "Internet+". University Education, 2018 (11): 8-12.

[14] Li Tongjie, Wan Chuanping, Li Zhongfang. Exploration of teaching reform of Theoretical Mechanics course for mechanical majors in applied undergraduate colleges and universities. Journal of Chifeng College, 2016, 32 (24): 206-207.

[15] Yu Fengchan, Zhai Pengfei, Heng Ting, et al. Several combinations of teaching theoretical mechanics courses in applied undergraduate programs. Agricultural Technology and Equipment, 2019 (3): 65-66.

[16] Hu Changlin. Research on engineering teaching reform strategy of theoretical mechanics course in applied undergraduate colleges and universities. Heilongjiang Science, 2022 (7): 150-152.

[17] Peng Shuai. Reform and exploration of teaching mode of Theoretical Mechanics under the background of engineering certification. Science and Technology Innovation Herald, 2019, 489 (21): 227-228.

