

On the Cultivation of Overall Analysis Ability by Theoretical Mechanics

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Abstract: In order to enable students to master the basic theoretical knowledge, basic ideas and methods of the course within a limited number of teaching hours. Based on this, the influence of theoretical mechanics on the overall analysis ability of students is studied. Firstly, according to the current situation of traditional theoretical mechanics teaching in most universities in China, the problems in traditional teaching are pointed out from three aspects: teaching content, teaching methods and assessment methods. Combined with project-based teaching, project selection, project team allocation, and project the implementation, project evaluation, questionnaire survey and result analysis have been explored and practiced. Finally, the combination of theoretical teaching and experimental projects, the use of the model of project-based teaching method, and the research-based teaching model are used to analyze the theoretical mechanics. A strategy for cultivating overall analytical skills.

1. Introduction

Theoretical mechanics is a discipline that studies the basic laws of mechanical motion of objects. It is both a branch of mechanics and the basis of various branches of general mechanics [1]. Theoretical mechanics is usually divided into three parts: statics, kinematics and dynamics. Statics studies the simplified theory of the force system acting on the object and the equilibrium condition of the force system [2]. Kinematics only studies the mechanical motion characteristics of the object from the geometric angle and does not involve the force of the object; the dynamics studies the relationship between the mechanical motion of the object and the force. Theoretical mechanics is a basic theory course for students of physics. Through learning, students should not only have a systematic understanding of the basic concepts and basic laws of macroscopic mechanical movement, but also master the general methods of dealing with mechanical problems, and then cultivate their solutions [3]. With the reform and deepening of the teaching system of higher education, the teaching objectives and teaching hours of theoretical mechanics have changed a lot [4]. At present, the traditional teaching mode of theoretical mechanics in most universities is mainly limited to knowledge transfer, and has shortcomings such as boring content, difficult to understand, and difficult to learn. Therefore, the traditional theoretical mechanics curriculum system and teaching methods are increasingly unable to meet the teaching needs. Teaching reform is imperative [5]. Combining teaching practice, this paper analyzes the teaching status quo of theoretical mechanics course, in order to enable students to master the basic theoretical knowledge, basic ideas and methods of the course within a limited number of teaching hours, taking into account the requirements of employment needs and ability training, The project-based teaching of theoretical mechanics courses has been explored and practiced [6].

2. Problems in the Teaching of Traditional Theoretical Mechanics

“Theoretical Mechanics” is a classic mechanics course. It is a theoretical physics course that deals with mechanics problems with advanced mathematics. General mechanics and advanced mathematics are used as advanced courses to enable students to understand and master the basic laws of mechanical movement. There is a certain repetition between the curriculum system and the general mechanics, which will inevitably affect the enthusiasm and initiative of students.

In the process of teaching, teachers mainly pay attention to the teaching and interpretation of the integrity of the curriculum knowledge system, resulting in a relatively simple teaching mode. Students only passively accept knowledge, and the subject status is not reflected.

The theoretical mechanics course is mainly based on the results of the assessment. The average score is 30%, which is mainly based on attendance, homework, and classroom answering questions. The final exam score is 70%. Most students usually do not spend too much energy [7]. As long as efforts are made to pass the final exam, the assessment method lacks supervision and evaluation of the learning process.

3. Exploration and Practice of Project-Based Teaching Method in the Teaching of Theoretical Mechanics

Table 1 Selection of theoretical mechanics course items

Serial number	Module	Project Description	Implementation focus
1	Newtonian mechanics	Particle motion law	Summarize the relevant content of the mechanics course, and illustrate the general ideas and methods for solving the mechanics problem with examples.
2		Momentum theorem and law of conservation of momentum	Applications
3		Angular Momentum Theorem and Angular Momentum Conservation Law	Applications
4		Kinetic energy theorem and law of conservation of mechanical energy	Applications
5		Non-inertial system	Similarities and differences between the method of solving the inertial system, Applications
6		Kinetic two-body problem	Applications
7		Motion of variable mass objects	Applications
8		Moment of inertia	Comparative Analysis of Calculation of Moment of Inertia of Different Shapes
9	Analysis mechanics	Principle of virtual work	General Ideas and Methods for Solving Mechanical Problems by Newton Analysis and Newtonian Mechanics
10		Lagrange equation	General Ideas and Methods for Solving Mechanical Problems by Newton Analysis and Newtonian Mechanics
11		Hamiltonian regular equation	General Ideas and Methods for Solving Mechanical Problems by Newton Analysis and Newtonian Mechanics
12		Hamiltonian principle	General Ideas and Methods for Solving Mechanical Problems by Newton Analysis and Newtonian Mechanics

3.1. Project selection

Project-based approach does not apply to all teaching content. The basic principle of selection is that students have certain basic content in the middle school and pre-mechanics courses; the part of analytical mechanics that can solve the same kind of mechanical problems with Newtonian mechanics; the knowledge points that are closely related to current science and technology can broaden students' thinking Apply theoretical knowledge to the solution of practical problems. Based on the above principles, the main contents of the theoretical mechanics course are sorted out, and 12 items are identified, which are particle motion law, momentum theorem and momentum conservation law, angular momentum theorem and angular momentum conservation law, kinetic energy theorem and mechanical energy conservation law. Non-inertial system dynamics, two-body problem, motion of variable mass objects, moment of inertia, principle of virtual work, Lagrange

equation, Hamiltonian regular equation, and Hamiltonian principle.

3.2. Project team allocation

Group students in class, pay attention to the collocation of students at different levels, form a study group, set up a team leader, and discuss the common problems in the project implementation and display process in small groups in the classroom.

3.3. Project implementation

According to the main body of the project and their respective tasks, through the network, books and other means to query the required knowledge, according to the needs of the relevant enterprises on-the-spot investigation, to obtain knowledge from practice.

3.4. Project assessment,

After the project is completed, the teacher randomly selects a student from the group members to report the implementation of the project. After the report is completed, the teachers and students are asked questions and evaluations. The teachers give objective and reasonable evaluations according to the tasks, seriousness and completion of the project team members, and play a positive guiding role in the implementation of the follow-up projects.

3.5. Questionnaire results and analysis

A total of 151 students from the 2016 and 2017 grades of Applied Physics in a university participated in the questionnaire. The questionnaire was taken in an anonymous form and the results were true and objective. The results of the questionnaire show that 89.1% of the students gave a positive attitude towards the implementation of the project-based teaching method in the theoretical mechanics course. 5.9% of the students could not adapt to the project-based teaching method, and it was very difficult to find a clue. There are also 5% of students who believe that the implementation of the project-based pedagogy is only a matter of individual outstanding students, and has nothing to do with themselves. It can be seen that in the implementation process of the project-based teaching method, teachers should pay full attention to the growth of each student while paying attention to the role of the team leader, pay attention to supervision, and provide timely guidance and suggestions to ensure the smooth development of the project.

The project teaching method is derived from the behavior-directed teaching method in Germany. It is a meaningful process of integrating students into a specific project. It promotes students' active self-learning, cooperative learning, active knowledge construction, and student knowledge acquisition. Capacity development is the highest goal [8]. The teaching content is delivered to the students in the form of projects, organically combining theoretical knowledge with teaching practices, mobilizing the enthusiasm of students, and improving students' ability to analyze problems and solve practical problems. Combined with the above content, the specific implementation process is as shown in Figure 1.

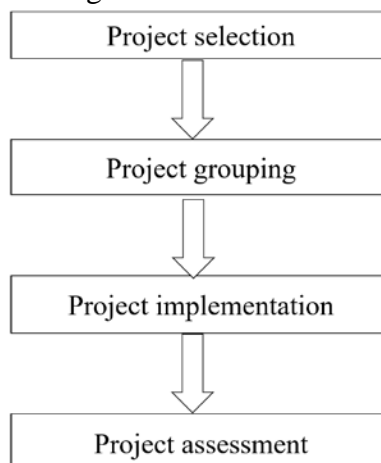


Fig.1. Implementation process of project teaching method

4. Theoretical Strategies for Teaching Strategies of Students' Overall Analytical Ability

4.1. Combination of theoretical teaching and experimental projects

The experimental system related to theoretical mechanics was constructed by purchasing animation software for simulation experiments, complete experimental equipment, and independent design and manufacturing. Through the virtual simulation experiment teaching of professional software, it is an ideal auxiliary way for students to participate in learning more freedom [9]. In combination with students' learning needs, they can selectively carry out relevant experimental projects, and at the same time design a certain number of open experimental projects, allowing students to participate in and complete experimental design, achieve the purpose of deliberative teaching, and enhance students' knowledge of “theoretical mechanics”. In the setting of experimental projects, attention is paid to enhancing the openness, comprehensiveness and design of experimental teaching [10], and using the links of the subject competition to enable students to comprehensively apply what they have learned.

4.2. Adopting the model of project-based teaching method

Project-based teaching not only avoids the repetition of the content of the mechanics course, but also maintains the systemic and completeness of the theoretical mechanics course. Students no longer feel boring, have a learning interest, can actively participate in the interaction between teaching and learning, improve the enthusiasm and initiative of students, and improve the teaching effect.

During the implementation of the project, the actual problems need to be solved by students, and students need to consult a large number of documents and professional books. If necessary, they need to contact relevant enterprises to strengthen the application and expansion of professional knowledge in practical problems.

Create an environment in which students learn independently, and involve as many students as possible in the teaching process. This helps develop students' self-learning skills, teamwork skills, and language skills, communication, and summarization skills.

The process assessment has been strengthened, and the timely feedback of the course teaching process has been strengthened, which is helpful for teachers to timely diagnose each student's shortcomings and problems in knowledge mastery and ability development. Understand the completion of the teaching objectives of the course and the students' comprehensive ability to use knowledge to enhance the timeliness of teaching.

4.3. Adopting research-based teaching mode

For the content of open courses, the research mode is used for teaching, for example, discussing the overturning of crane lifting weights and how to prevent the mechanical problems of overturning. Compared with traditional teaching methods, research-based curriculum teaching emphasizes cognitive results and emphasizes the use of knowledge, so that students can know what, why, and where and how to apply relevant knowledge points. This method is used throughout the teaching, focusing on allowing students to fully understand and master the practical-theory-practical research-based teaching mode of “theoretical mechanics”. In the teaching process, students are the mainstay and teacher-led, starting from the actual level of students, taking into account the students' interest and growth characteristics, giving full play to students' autonomy, initiative and creativity.

Finally, theoretical mechanics has an important influence on students' overall analytical ability. For example, it promotes students' active self-learning, cooperative learning, and active knowledge construction, with students' knowledge acquisition and ability development as the highest goal. Combined with the above, the specific teaching strategy can be divided into three parts, as shown in Figure 2.

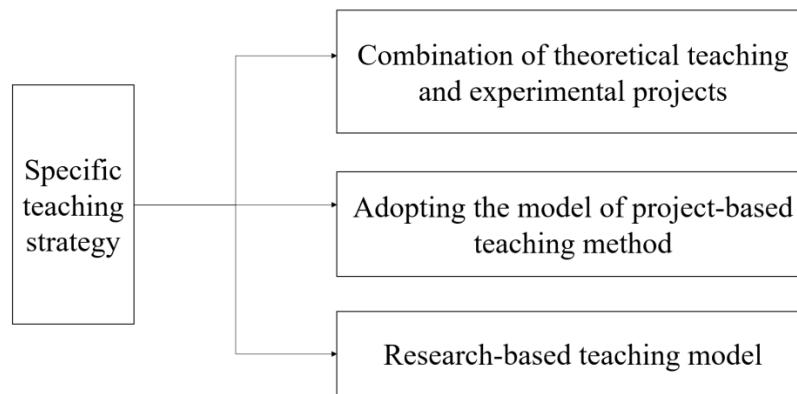


Fig.2. Analysis of teaching strategies of theoretical mechanics on students' overall analytical ability

5. Conclusion

Firstly, the problems existing in the teaching of traditional theoretical mechanics are analyzed. Then the exploration and practice of the project-based teaching method in the teaching of theoretical mechanics are analyzed. Based on the real project practice cases, the students are surveyed. The study found that the project-based teaching method can effectively improve the classroom teaching effect and promote the transformation from knowledge transfer to comprehensive ability training. However, the project-based teaching method is not applicable to all teaching content. The follow-up research will focus on how to properly select the project, organically combine the project-based teaching method with the traditional teaching method, and strengthen the teacher's effectiveness in the teaching process. Supervision and guidance, deepening the teaching reform of theoretical mechanics courses, etc.

Acknowledgement

Key construction course project of Northeast Petroleum University: Theoretical Mechanics Course Construction Project

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