Exploration and Practice of the "One-Student-Two-Tutors" Community through Integrating "1 +3 Teaching Resources" into Undergraduate Experimental Teaching

Yongming YANG, Dongfang TU, Yan YU, Shengwei YAO, Wei ZHANG, Shuangyuan WANG, Pengyun DUAN, Weiyu NI, Wencui LIU

Public Experiment Center, University of Shanghai for Science and Technology, Shanghai 200093, China

Abstract This study closely follows the spirit of the first class undergraduate education action plan (2021 -2025) of University of Shanghai for Science and Technology, combines with the national first-class undergraduate professional training plan of mechanical design and manufacturing and automation, and carries out the exploration and practice of "1 +3 teaching resources" integrating into the "One-Student-Two-Tutors" community of undergraduate experimental teaching. On the basis of creating a good learning environment and creating an excellent learning platform, this paper studies the undergraduate experimental teaching of the trinity of "theoretical courses + experimental courses + innovation and entrepreneurship activities, discipline competitions, and scientific research project activities". This study has a certain reference value for colleges and universities to cultivate outstanding engineering talents with happy learning attitude, scientific research interest, practical ability and innovative ability.

Key words "1 +3 teaching resources", "One-Student-Two-Tutors" community, Undergraduate experimental teaching

1 Introduction

Experimental teaching activity is an essential part in the cultivation of undergraduates[1]. In recent years, the "double first-class initiative" construction strategy[2-4] put forward by the Ministry of Education has pointed out the direction for undergraduate experimental teaching in colleges and universities, aiming at improving the operational thinking ability, analytical thinking ability and innovative thinking ability of undergraduates, and focusing on cultivating outstanding engineering talents. Zhang Wei *et al.*[5] carried out the exploration and research on the reform and innovation of public basic experimental teaching in colleges and universities. Through the reform and innovation of teaching management, the quality of experimental teaching, the management level of experimental center and the goal of cultivating innovative talents can be improved. Wang Li *et al.*[6-7] discussed the role of innovative experimental teaching in the cultivation of undergraduate ability and the integration of scientific research projects into undergraduate experimental research in the context of "double first-class initiative", and pointed out that the integration of scientific research projects into undergraduate experimental teaching activities can better cultivate students' interest in participating in experiments, which has a good reference significance for the cultivation of innovative talents and the innovation of experimental teaching mode. Sun Ying *et al.*[8] carried out research on cultivating innovative talents in professional basic courses under the background of "double first-class initiative", and proposed to pay attention to heuristic teaching, apply case teaching method, and create problem situations, so as to cultivate students' innovative consciousness. Yang Yongming *et al.*[9] carried out a study on laboratory safety and management in colleges and universities in the context of "double first-class initiative", systematized and modularized laboratory safety and management, professionalized teachers, and created a good laboratory safety and management culture system, which is conducive to firmly establishing "safety concept" and "red line consciousness" for teachers and students, and cultivating students' comprehensive quality. It has a certain reference value for the scientific development of university laboratories. The mechanical principle is directly related to aviation, aerospace, aircraft carriers and other "Pillars of a Great Power ", which is very important for China's construction of a modern socialist country.

Mechanical principle experiment is the main way for students to deepen theoretical cognition, understand abstract concepts and apply basic knowledge. Its main task is to cultivate students' basic skills and comprehensive quality in the field of mechanical engineering. In addition, it pays attention to the cultivation of undergraduates' operational thinking ability, analytical thinking ability and innovative thinking ability. In this study, we discussed the exploration and practice of the integration of "1 +3 teaching resources" into the "one-student-two tutors" community of undergraduate experimental teaching, and on the basis of creating a

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Yongming YANG, experimenter, research fields: mechanical basic experimental teaching, laboratory safety and management.

good learning environment and creating an excellent learning platform, and the trinity of undergraduate experimental teaching of "theoretical courses + experimental courses + innovation and entrepreneurship activities, discipline competitions, and scientific research project activities". This study can provide some reference value for colleges and universities to cultivate outstanding engineering talents.

2 Analysis of pain points in experimental teaching

In view of some core pain points in the current experimental teaching system, we made the following in-depth analysis.

Firstly, the traditional teaching mode is often teacher-centered, ignoring the dominant position of students in teaching activities, coupled with the lag of teaching methods, it is difficult to stimulate students' enthusiasm and interest in active learning, resulting in students' participation in the experimental process is generally low.

Secondly, the update speed of teaching content lags behind, fails to reflect the latest trends and needs of the industry in time, and is seriously out of line with the actual needs of enterprises, which limits the development of students' ability to effectively transform theoretical knowledge into practical ability.

Thirdly, the lack of interdisciplinary integration and the lack of interdisciplinary comprehensiveness and challenge in the design of experimental projects make it difficult to cultivate students' comprehensive literacy and innovative ability. Besides, the experimental teaching lays too much emphasis on the inculcation of content and the writing of experimental reports, while ignoring the exploratory, experiential and practical nature of the experimental process, which is not conducive to the formation of solid experimental skills and scientific thinking for students.

Furthermore, the lack of process assessment mechanism is also a major drawback of the current experimental teaching. Over-reliance on the final experimental report or examination results as the criteria for evaluating students' experimental ability, ignoring the evaluation and feedback of students' performance in the experimental process, can not comprehensively and accurately reflect the true level and progress of students.

In particular, the educational function of experimental teaching needs to be further improved. Experimental teaching is not only a process of imparting knowledge and cultivating skills, but also an important way to shape students' scientific spirit, innovative thinking and team cooperation ability. However, the current experimental teaching is still insufficient in this respect, which needs further exploration and practice.

Therefore, in view of the above problems, it is urgent to carry out a comprehensive reform and innovation of the experimental teaching system, aiming at enhancing students' interest and participation in the experiment, optimizing the teaching content and means, promoting the integration of disciplines and project challenges, strengthening the process assessment and practical ability training, and improving the educational function, so as to construct a new experimental teaching mode that meets the needs of the times and the requirements of talent cultivation.

3 Integrating "1 + 3 teaching resources" into the "one-student-two-tutors" community of undergraduate experimental teaching

3.1 Construction of "one-student-two-tutors" community and "1 +3 teaching resources" Taking the Mechanical Principle Experiment, a first-class undergraduate course construction project of University of Shanghai for Science and Technology in 2024, as an example, we constructed a "one-student-two-tutors" community (Fig. 1) in which "1 +3 teaching resources" are integrated into undergraduate experimental teaching, and constructed a "1 + 3 teaching resources" database (Fig. 2). The "one-student-two-tutors" community "means that the undergraduates who take the experiment of mechanical principles as the core subject of experimental teaching, and the diversified team of teachers who integrate the theoretical course teachers of mechanical principles with the experimental course teachers of mechanical principles as the leading force of experimental teaching, also integrating doctoral students, master students and undergraduates who have studied mechanical principle experiments as experimental teaching peer tutors. "1 +3 teaching resources" refers to the construction of a knowledge graph covering the knowledge points of classical mechanical principle experiments, and the integration of excellent cases of innovation and entrepreneurship, excellent cases of academic competitions and excellent cases of scientific research projects participated by undergraduates who study mechanical principle experiments into the experimental teaching process in real time, so as to make mechanical principle experiments have four characteristics of practicality, innovation, challenge and frontier.

3.2 Application of experimental teaching cases When discussing the experiment of mechanism motion diagram drawing in the experimental teaching of mechanical principle, we selected the undergraduates who took the experiment as the main body of teaching, and constructed a diversified teaching team with the participation of teachers of mechanical principle theory and experimental courses to dominate the experimental teaching process. In addition, we also used doctoral students, master students and undergraduates who have studied mechanical principle experiments as peer tutors to form a diversified experience passing mode. In order to enhance the teaching effect, we constructed a knowledge graph of the classical knowledge points of the mechanism motion diagram of experiment (Fig. 3). The knowledge graph not only provides strong support for the experimental teaching of the teacher-student community, but also enriches the teaching resources. These resources include classic innovation and entrepreneurship cases, excellent discipline competition cases and high-level scientific research project achievements (as shown in Fig. 2), which effectively broaden students' professional horizons.

In the process of experimental teaching, we innovatively adopted the closed-loop teacher-student two-way interactive discussion teaching method of "1 up and 1 down + 1 inside class and 1 outside class", as shown in Fig. 4. This teaching method deeply excavates the cross-border integration and innovation of interdisciplinary, and gives full play to the appeal and attraction of the course. In class, we combine the teaching method of "online + offline" to guide students to self-organize learning. After class, we encourage students to actively participate in innovation and entrepreneurship, academic competitions and scientific research projects through the "online + offline" approach, so as to enhance the practicality, innovation, challenge and frontier of the mechanical principle experiment course in real time. This teaching mode not only creates a good learning environment, but also provides an excellent learning platform for students, which helps to cultivate their learning attitude, research interest, practical ability and innovation ability. Finally, this teaching mode has significantly improved the quality of undergraduate education and the quality of talent cultivation.

It is particularly worth mentioning that, excellent cases of innovation and entrepreneurship participated by undergraduates taking mechanical principle experiments (such as "Multifunctional Vegetable Seeder", a project of Shanghai Municipal College Students' Innovation and Entrepreneurship Training Program in 2024), excellent cases of discipline competition (such as "Shangli Science and Technology Park Cup", "Qingqingzijin Youyouwoxin" in the tenth China International College Students Innovation and Entrepreneurship Competition of Shanghai University of Science and Technology Classical resources such as "Research on High-end Gear Grinding Technology and Its High-precision On-machine Detection Technology" and "Experimental Teaching Platform for Rehabilitation Training of Intelligent Limbs" have been incorporated into the "1 + 3" teaching system in real time. It promotes the renewal iteration and optimization design of mechanical principle experimental projects and teaching activities. This process not only forms a closed loop of teacher-student community teaching and learning, but also greatly improves the students' learning drive, stimulates their interest in autonomous learning, makes their learning enthusiasm comprehensively improved, and the experimental teaching effect also achieves a qualitative leap.

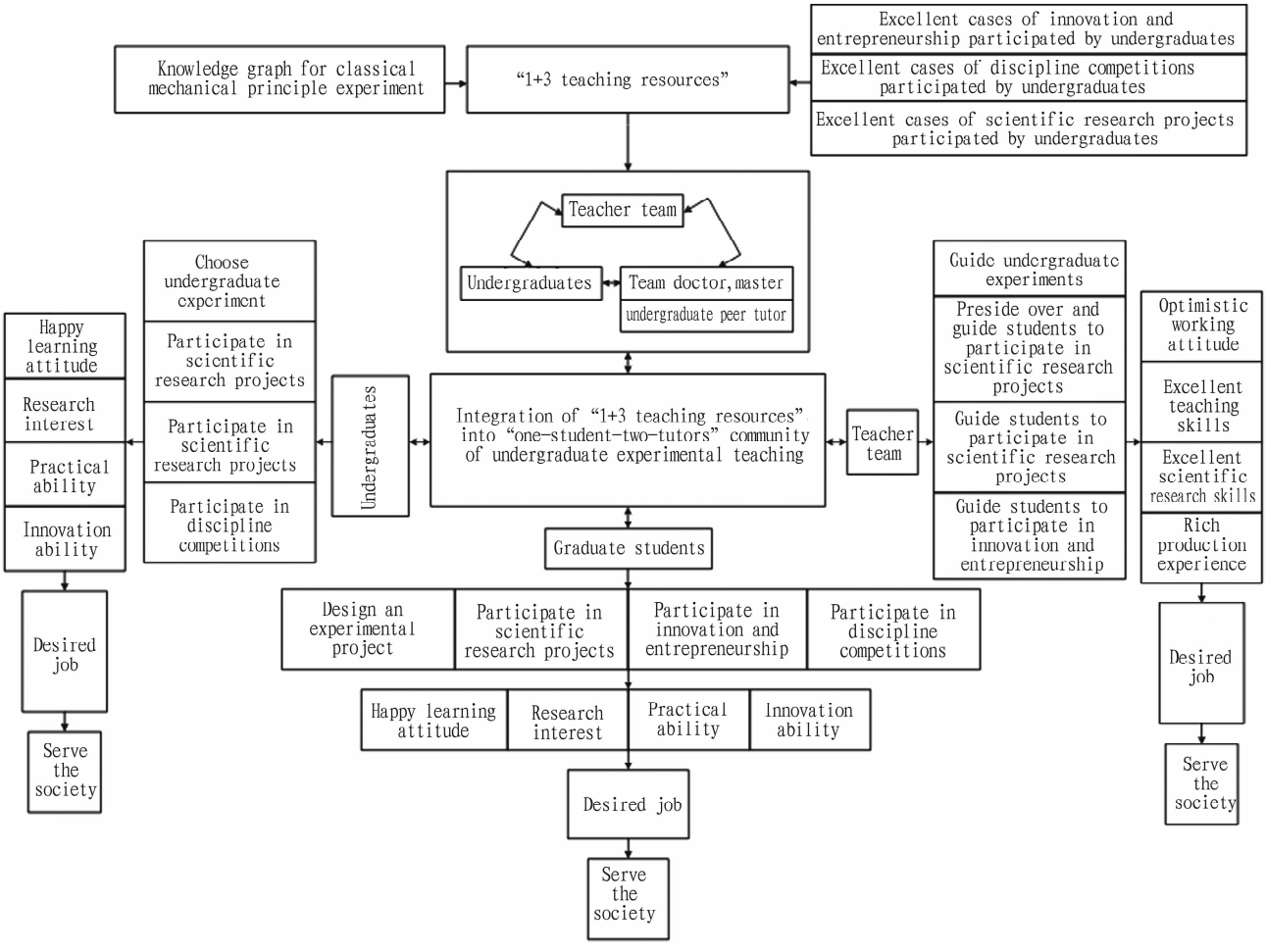

Fig. 1 Integration of "1 + 3 teaching resources" into "one-student-two-tutors" community of undergraduate experimental teaching

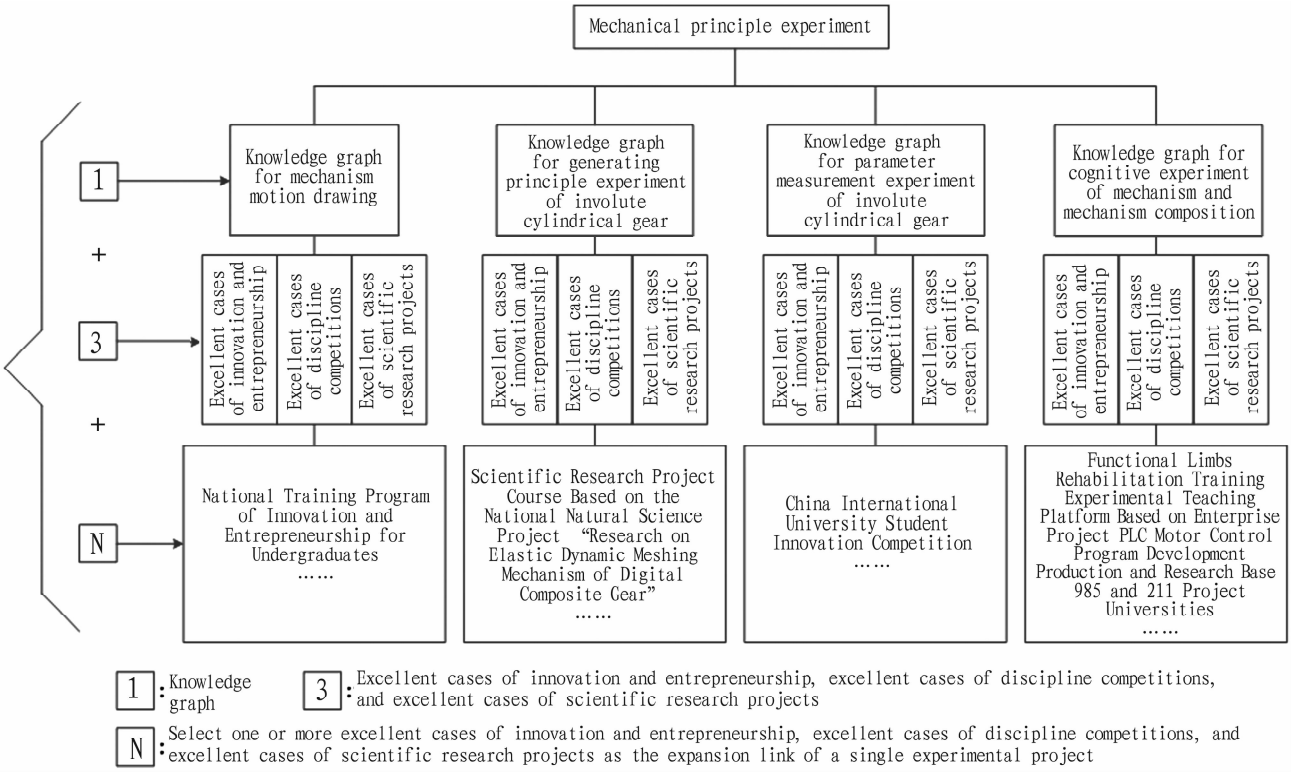

Fig. 2 "1 +3 teaching resources"

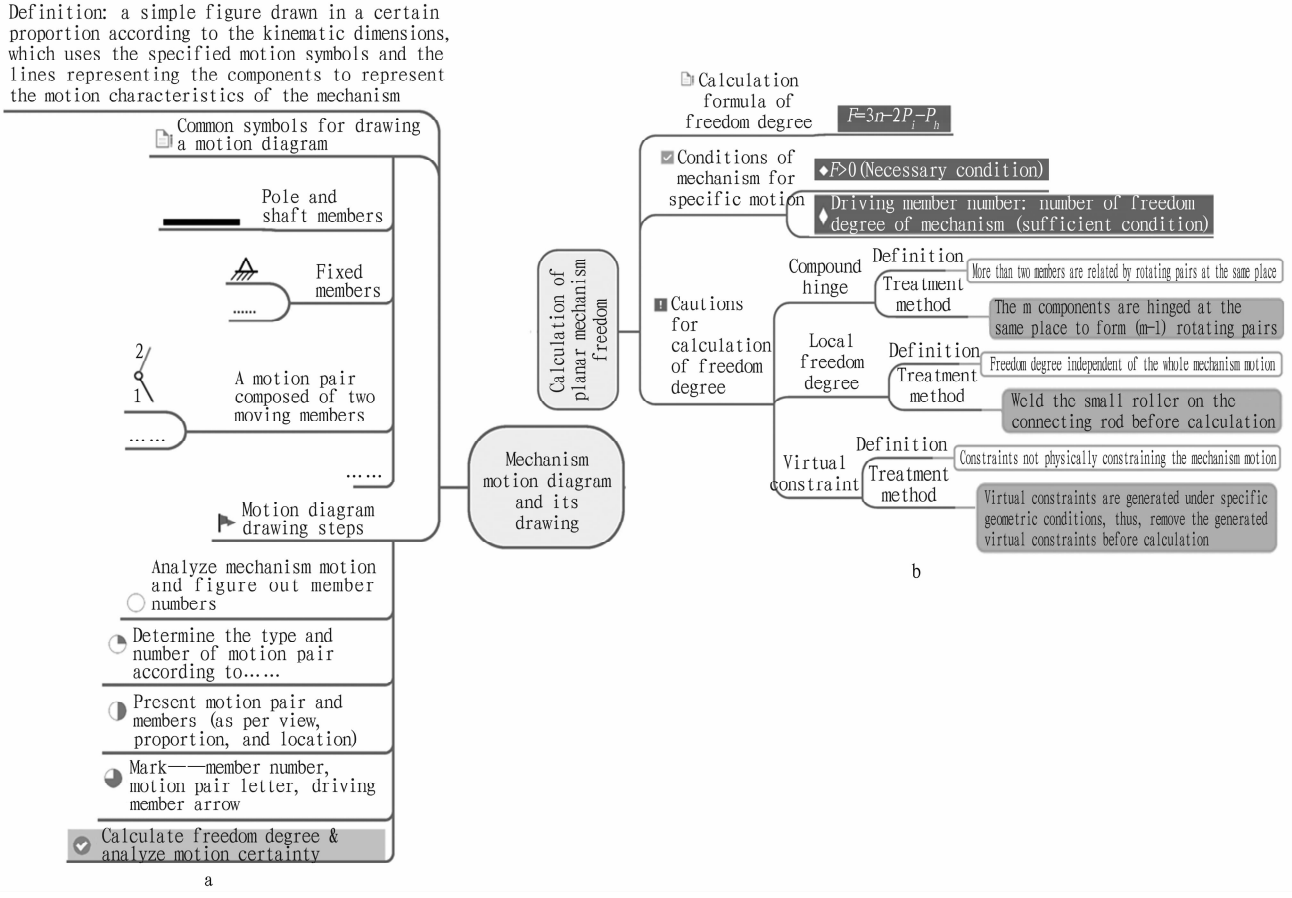

Fig. 3 Classic knowledge points and knowledge graph for mechanism motion diagram

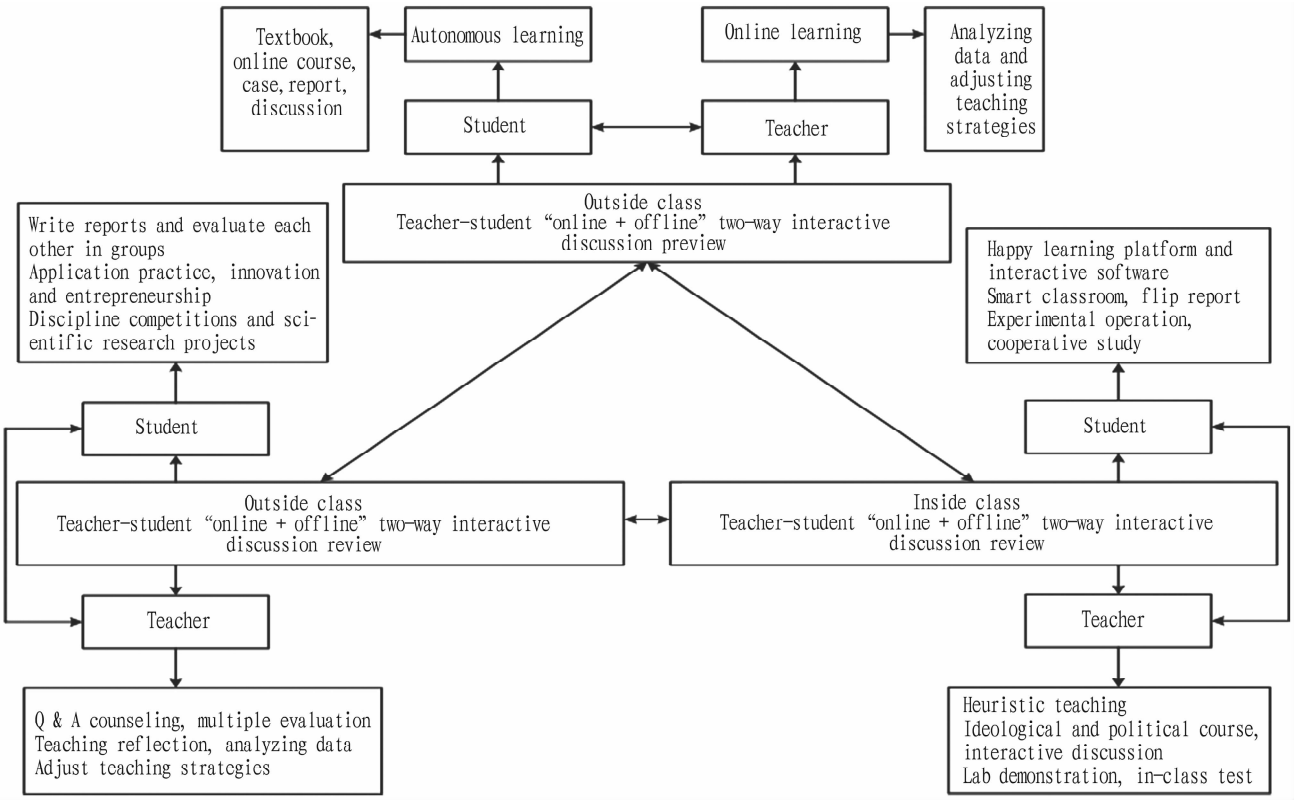

Fig. 4 Closed-loop teacher-student two-way interactive discussion teaching method of "1 up and 1 down +1 inside class and 1 outside class"

4 Conclusions

Practice has fully proved that the integration of "1 +3 teaching resources" into the "one-student-two tutors" community mode of undergraduate experimental teaching has a significant effect on enhancing students' internal learning motivation. This mode not only effectively stimulates students' interest in autonomous learning, makes them more willing to learn, but also comprehensively improves students' learning enthusiasm and experimental teaching effect. This innovative teaching mode undoubtedly has important reference value and practical significance for colleges and universities to devote themselves to cultivating outstanding engineering talents.

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