

Research on Management Strategies of the Dual Mentor Team for Master's Degree Postgraduates of Mechanical Engineering

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Abstract: With the increasing demand for the quality of postgraduate training in mechanical engineering, the existing tutor team management mechanism has deficiencies in the implementation of tutor responsibilities, collaborative guidance between school and enterprise tutors, and comprehensive development of graduate students' abilities. To this end, this paper introduces the "dual tutor system" management strategy to construct a tutor team management system jointly guided by academic tutors on campus and enterprise practice tutors. This study promotes the multi-dimensional improvement of professional ability, comprehensive ability and development ability by improving the evaluation and assessment mechanism of mentors, strengthening communication and cooperation between mentors both inside and outside the school. The research combines teaching practice, designs a reasonable training program and credit structure, and ensures the deep integration of theory and practice. Empirical analysis shows that the experimental group with the dual tutor system is significantly better than the control group with the traditional single tutor system in all ability dimensions. Specifically, the average professional ability score of the experimental group is 87.6, which is significantly higher than 83.2 in the control group, and the difference is statistically significant ($P=0.041$), indicating that the dual tutor system effectively improved students' professional knowledge mastery and application ability. The dual tutor system significantly improves the professional practice ability and innovative development ability of graduate students, optimizes the quality of tutor guidance and the effect of graduate training, and provides an effective path and management reference for the high-quality training of mechanical master students.

1. Introduction

With the continuous development of higher education and the acceleration of industrial upgrading in China, professional degree graduate education, as an important way to cultivate high-level applied talents, is increasingly receiving widespread attention from society and

universities. As a key pillar discipline in China's manufacturing and equipment manufacturing industries, the mechanical major has put forward higher requirements for the quality of talent training. The traditional single-tutor guidance model can no longer meet the needs of professional degree graduate students to improve their theoretical knowledge and practical ability at the same time. The dual-tutor system comes into being and becomes an important measure to improve the comprehensive quality and innovation ability of graduate students. The dual-tutor system achieves a deep integration of theory and practice through the collaborative guidance of on-campus academic mentors and corporate practice mentors, which helps to promote graduate students to better adapt to industry development and job requirements.

Based on the actual needs of mechanical master's degree training, combined with the relevant experience of the dual tutor system at home and abroad, this paper systematically analyzes the problems and shortcomings in the construction of the existing dual tutor team, and puts forward targeted management strategies and improvement measures. Through empirical research on indicators such as the frequency of dual tutor guidance, tutor satisfaction, and student ability improvement, the effectiveness and feasibility of the management strategy are verified. The research aims to build a more efficient collaborative education platform for universities and enterprises, promote the continuous improvement of the quality of professional degree graduate education, promote the deep integration of industry, academia, and research, and achieve a win-win situation for talent training and industrial development.

Starting from the dimensions of acquisition and development of professional degree graduate students' abilities, the paper clarifies the role of the dual tutor system in promoting professional ability, general ability and development ability; then it systematically expounds on the construction of tutor evaluation and assessment mechanism, emphasizing dynamic evaluation of the whole process and multi-dimensional performance feedback; then it draws on the concept of Germany's "dual system" and proposes a strategy for building a "dual-teacher" tutor team; then it discusses measures to strengthen the social tutor team, including tutor selection principles, school-enterprise collaboration mechanism, etc.; finally, combined with the actual training program for masters of mechanical engineering, it analyzes the integration of the dual tutor system in the curriculum system, practical links and thesis guidance, and constructs a feasible management optimization strategy system.

2. Related Work

In the context of the continuous changes in higher education and the rapid development of artificial intelligence technology, domestic and foreign scholars have conducted multi-dimensional research on topics such as mentoring, teaching evaluation, informal learning and capacity building. The following literature review shows the latest progress and multiple exploration paths in related fields. Wei and Yu explored the supporting role of chatbots such as ChatGPT in foreign language learning in the context of the AI era, and pointed out that the traditional teaching-testing evaluation method can no longer fully reflect the knowledge and skills acquired by students through informal learning. They proposed the use of alternative evaluation methods to more realistically reflect the actual performance of students under the assistance of AI, and explored its characteristics, forms, advantages and integration in second language teaching [1]. Yusubova and Knoben interviewed 18 mentors in Belgian accelerators and incubators to explore the motivations and roles of business and social entrepreneurship mentors. The study found that the two types of mentors have both similarities and differences in motivation and function [2]. Chukwu et al. explored the training and mentor support needs of junior researchers in the health system in an embedded research environment to promote the realization of the "five health goals" (patient experience, medical staff

experience, group health, medical value, and health equity) [3]. Hallmann et al. found through a survey of 105 elite athletes and 101 business mentors that mentors' investment in career development and performance value delivery helps to improve athletes' satisfaction with multiple career goals and also improve mentors' own satisfaction and sense of accomplishment [4]. Based on social perception theory and jealousy subtype theory, Liu et al. explored how the initiative of the mentored in the workplace affects their knowledge sharing or concealment behavior by triggering benign or malignant jealousy in mentors. The study found that if the mentored is active and well-intentioned, the mentor is more likely to have benign jealousy and be willing to share knowledge [5]. Gabi et al. reviewed the issue of "degree awarding gap" in UK higher education, emphasizing the key role of personal tutor system in promoting racial equality in addition to curriculum decolonization. Through literature and policy analysis, it is pointed out that PT can enhance student participation and improve learning experience[6]. Bikanga Ada and Foster investigated graduate students' views on the Modified Team Learning (TBL) teaching method and the effect of Bootcamp courses on improving their practical skills. The results showed that students' practical experience was significantly improved, teamwork evaluation was positive, and most students were more confident in subsequent courses[7]. Sheng et al. analyzed the influencing factors of the graduate talent training program in art design at Shenyang University in Liaoning Province through quantitative methods. The results showed that the graduate training system has direct and indirect effects on the training quality, and the graduate source structure has a direct impact on the training quality[8]. Cram et al. proposed and evaluated solutions to the teaching difficulties of large-scale practical mathematics courses (such as basic finance) through design research methods. The results showed that unified learning materials, interactive online content, strengthening teacher-student connections, continuous support assessment, and emphasis on content application can effectively improve student learning outcomes [9]. Vainieri et al. designed a 1.5-hour workshop and podcast assessment to help graduate students improve their scientific research communication capabilities for non-professional audiences. Through workshop training and the production of a 10-minute scientific research podcast, students' self-confidence was significantly improved. Feedback from teachers and students showed that the assessment effectively promoted scientific communication skills [10]. Lowe introduced the "Entering Master's Study" series of lectures at the University of Winchester. By popularizing information on the practice, selection, and economy of graduate study, it helps fifth-level students break down barriers, make wise choices, and promote equity in graduate education, which can be used as a reference for other universities [11]. Although existing research has explored the mentor mechanism, teaching evaluation methods and capacity building models from different perspectives, there are still bottlenecks such as fragmentation, insufficient empirical support and insufficient application depth in theoretical integration, practical path implementation, scientific nature of evaluation mechanisms and the effectiveness of dual mentor collaboration, which urgently need to be broken through through systematic research.

3. Method

3.1 Master's Degree Graduate Student Competency Development Indicator System

The acquisition and development of professional master's degree students' abilities is an important indicator of their training quality. The growth process of students directly reflects the overall level of the tutor team and their guidance effect. Based on this, this study uses the performance of professional master's degree students in the acquisition and development of abilities as an important basis for evaluating the quality of professional degree education. Combined with the actual application scenarios of abilities, the abilities of professional master's degree students can

be divided into three categories:

Professional ability: It refers to the graduate student's in-depth understanding and mastery of the knowledge, technology and methods of the major and related industries, and the ability to analyze, judge and propose solutions based on practical problems. Professional ability is the foundation for graduate students to engage in professional and technical work, and is also the core indicator for measuring their academic level and professional competence.

General skills: It covers communication and coordination, teamwork, management, interdisciplinary learning and other skills. These skills can be widely transferred and applied in different majors and industries. The improvement of general skills will help postgraduates better adapt to the complex and changing working environment and diversified career needs.

Development ability: It belongs to a higher level of ability. It is to integrate innovative thinking and independent learning ability on the basis of professional ability and general ability, and can break through traditional cognition and promote technological progress and innovative practice. Development ability reflects the comprehensive quality and future growth potential of graduate students, and is the key to cultivating high-level compound talents.

These three types of abilities are interrelated and together constitute an evaluation system for the comprehensive qualities of graduate students. They are the core content of the quality of professional degree graduate education.

3.2 Construction of Evaluation and Assessment Mechanism for Graduate Tutors

Improving the quality of the tutor team is inseparable from a scientific evaluation and assessment mechanism. A perfect evaluation system can not only motivate excellent tutors but also promptly discover and correct existing problems to ensure the effective performance of tutors' duties. The specific mechanism should include the following aspects:

Full-process dynamic evaluation: An evaluation model combining individual guidance of tutors with collective guidance of teams has been established. By refining the assessment indicators and dynamically tracking the guidance work of tutors, we pay attention to both the quantitative workload and the quality of guidance. At the end of the term of appointment, tutors should submit a summary of their scientific research, teaching and guidance work, which will be comprehensively assessed by the Academic Committee.

Multi-dimensional comprehensive assessment: Assessment indicators cover scientific research results, teaching quality, graduate management education, etc., to ensure that tutors not only make academic contributions but also play an active role in cultivating graduate students. Specific assessment contents include the number and effect of guidance, the rationality of the change of thesis proposal and thesis title, the quality of paper publication, blind review of degree thesis and selection of excellent papers, etc.

Improve the reward and punishment system: for tutors who fail to fulfill their guidance responsibilities or whose guidance results are poor, disciplinary measures such as public criticism, deduction of allowances, suspension of enrollment and even disqualification will be implemented; for tutors with outstanding performance, scientific research and teaching awards will be given to form a management atmosphere that emphasizes both incentives and constraints.

Through this mechanism, the school can effectively manage the tutor team, encourage tutors to actively assume guidance responsibilities, and promote the steady improvement of the quality of postgraduate training.

3.3 Learn from Germany's "Dual System" to Promote the Construction of a "Dual-qualified" Tutor Team

Germany's "dual system" vocational education model is a model for achieving deep integration between schools and enterprises and cultivating high-quality application-oriented talents. It has important reference significance for the construction of the dual tutor system for professional degree graduate students in China. Its core features include:

(1) Collaborative education between schools and enterprises

Based on the job requirements of enterprises, theoretical teaching and practical training plans are formulated. Students have the dual identities of learners and enterprise employees. They not only learn professional theoretical knowledge but also participate in production-line practical training.

(2) Close integration of theory and practice

Students receive practical training in an enterprise environment, and their theoretical knowledge and practical operations are improved simultaneously, ensuring that the students can quickly adapt to job requirements.

(3) Meeting the needs of industry development

The training content is dynamically adjusted to keep up with the latest standards of enterprise and industry development, effectively promoting the precise connection between talent training and social needs.

Although there are differences between the "dual system" and the training of full-time professional degree graduate students in China, its concepts of "school-enterprise cooperation" and "dual tutor system" provide important inspiration for the construction of a "dual-teacher" tutor team for mechanical master's programs in China, especially in improving tutors' practical guidance capabilities and enhancing the adaptability of training programs.

3.4 Strategy for Building a Team of Social Mentors

As an important supplementary force in graduate education, the stable development and effective management of social mentors are particularly critical to improving graduate students' practical ability. The main measures include:

The principle of "student-centered, based on disciplines and majors" should be adhered to, and social mentors with rich industry experience and professional skills should be selected to ensure that they can truly meet the needs of disciplines and majors and student development. Social mentors should be key talents with high professional level and good reputation in the industry, who can provide students with cutting-edge technical guidance and career development suggestions.

The interactive cooperation between on-campus tutors and social tutors should be strengthened. The two types of tutors have different guidance focuses. On-campus tutors focus on theoretical teaching and scientific research, while social tutors focus on practice and innovative entrepreneurship. The school should promote exchanges between the two sides in guidance methods, educational concepts and scientific research cooperation, promote the formation of complementary advantages, and build a coordinated development of the "double-qualified" tutor team.

A diversified management and incentive mechanism should be established to stimulate the enthusiasm of social mentors and ensure their long-term participation in postgraduate training by improving the methods of employing, assessing and motivating social mentors.

3.5 Training Program for Mechanical Professional Degree Masters and Implementation of the Dual Tutor System

In combination with the excellent engineer training system of mechanical engineering, the

full-time professional degree master training program of our school emphasizes the combination of theory and practice. The main features are as follows:

The training mode is diverse and flexible. Course learning, professional practice and degree thesis are mutually integrated. The practice time is no less than 6 months, and the degree thesis is generally no less than 1 year. The flexible design of the school system meets the personalized growth needs of different students.

A dual-tutor system is implemented. Each graduate student is assigned an on-campus tutor and an enterprise tutor. The on-campus tutor is mainly responsible for formulating training plans, guiding academic and paper writing, and organizing thesis defense; the enterprise tutor is responsible for guiding students' corporate practice and helping students apply theoretical knowledge to actual production and technology development.

Scientific credit setting. The total credits are no less than 36 credits, including no less than 16 credits for degree courses, no less than 4 credits for applied courses, and no less than 6 credits for professional practice, to ensure that students have a solid theoretical foundation and strong practical ability.

This training program not only strengthens academic research capabilities but also focuses on improving practical skills, and cultivates students to become high-level applied talents that meet the needs of the machinery industry.

The above content systematically explains the management strategy of the dual-tutor team for mechanical professional degree master's students. From the ability indicator system, tutor assessment, school-enterprise collaboration model, social tutor construction to specific training programs, it comprehensively covers the key links to improve the quality of the tutor team and the quality of postgraduate training, and provides a theoretical basis and practical guidance for promoting the scientific management and efficient implementation of the dual-tutor system.

4. Results and Discussion

4.1 Experimental Subjects

The full-time master's students of the Mechanical Engineering major of University A in 2023 are selected as the experimental samples, with a total of 100 people.

Experimental group: 50 students guided by the "dual mentor system" (on-campus mentor + enterprise mentor);

Control group: 50 students guided by only on-campus mentors.

4.2 Experimental Variables

Independent variable: tutor guidance method (dual tutor system vs. single tutor system);

Dependent variable: students' three types of ability development levels (professional ability, general ability, development ability);

Control variables: students' admission scores, gender ratio, tutor qualifications, course setting consistency, etc.

4.3 Experimental Tools and Measurement Methods

Semi-structured interviews: 10 students in the experimental group and 10 students in the control group are interviewed to collect subjective evaluations on the quality of tutor guidance, corporate practice experience, thesis topic selection and employment support.

Grade and achievement recording method: It collects each student's:

Proposal and mid-term examination grades;
 Quality of degree thesis (blind review grades);
 Publication of academic papers/patents;
 Feedback evaluation of internship units.

4.4 Data Processing and Analysis Methods

In order to deeply explore the actual effect of the dual-tutor system in the training of mechanical professional master's degree students, this paper systematically presents the comprehensive advantages of the dual-tutor mechanism in terms of student ability development, practical results output, employment performance, and tutor guidance satisfaction by comparing and analyzing the quantitative data of the experimental group and the control group.

Table 1 Comparison of students' ability scores (experimental group vs control group)

Competency Dimension	Experimental Group Mean (n=50)	Control Group Mean (n=50)	Significance (P-value)
Professional Competency	87.6	83.2	0.041*
General Competency	85.1	78.5	0.003**
Development Competency	82.9	74.7	0.001**
Overall Competency Mean	85.2	78.8	0.002**

Note: * indicates $P < 0.05$, ** indicates $P < 0.01$, which are statistically significant.

The Table 1 show that the experimental group using the dual tutor system is significantly better than the control group using the traditional single tutor system in all ability dimensions. Specifically, the average professional ability score of the experimental group is 87.6, which is significantly higher than the 83.2 of the control group, and the difference is statistically significant ($P=0.041$), indicating that the dual tutor system effectively improves students' professional knowledge and application ability. In terms of general ability, the experimental group scores 85.1 and the control group scores 78.5, and the difference between the two groups is more significant ($P=0.003$), indicating that the dual tutor system has significant advantages in promoting students' communication, teamwork and learning ability and other general skills. As a higher-level innovation and breakthrough ability, the experimental group's development ability is 82.9, far exceeding the control group's 74.7, and the difference is extremely significant ($P=0.001$), reflecting that the dual-tutor system can stimulate students' independent innovation potential and cross-border integration ability. In terms of the average comprehensive ability, the experimental group is 85.2, and the control group is 78.8, which is significantly improved ($P=0.002$), further confirming the positive impact of the dual-tutor system on the comprehensive quality of graduate students.

There is a clear positive correlation between the frequency of tutor guidance and the level of graduate student ability development. Specifically, when the guidance frequency is no more than 4 times per semester, the average scores of graduate students in professional ability, general ability and development ability are 82.5, 79.3 and 75.1, respectively, which are generally at a low level. With the increase in the frequency of guidance, the performance of students in various abilities has been significantly improved. When the guidance frequency is in the range of 5-7 times, the average score of professional ability increases to 86.7, the general ability reaches 84.2, and the development ability also rises to 80.5, indicating that more frequent tutor communication helps graduate students to make comprehensive progress in knowledge understanding, communication and collaboration, and innovative thinking, as shown in Figure 1.

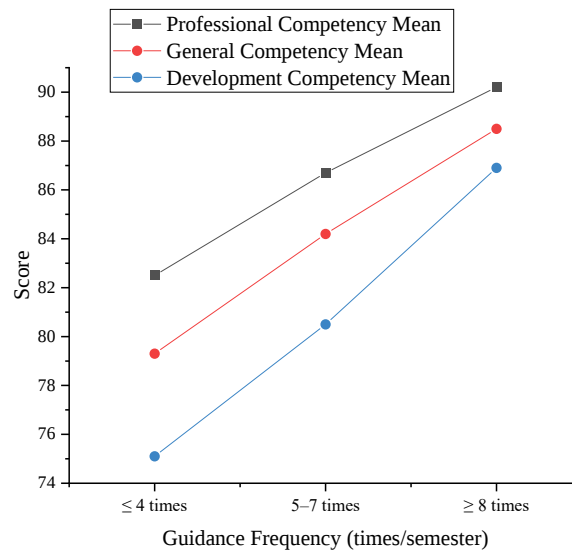


Figure 1 Correlation analysis table between tutor guidance frequency and student ability scores (experimental group)

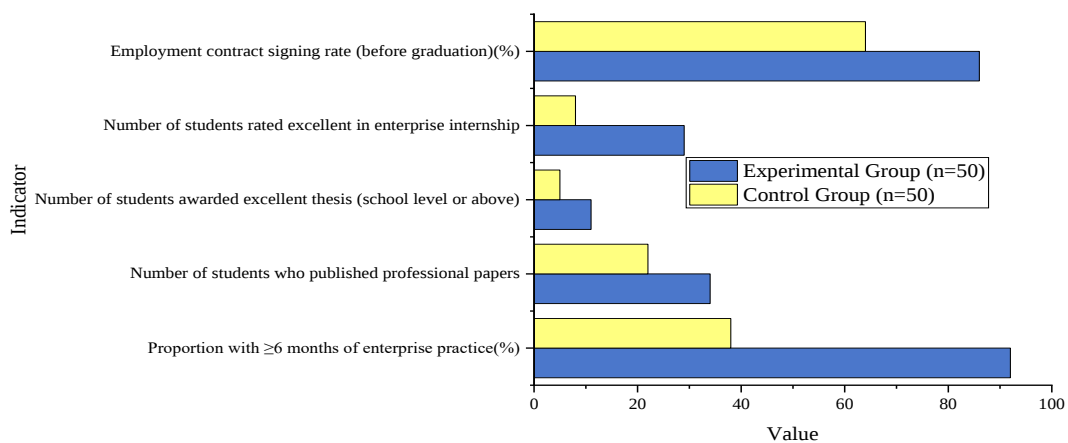


Figure 2 Statistics of students' practice and scientific research results (experimental group vs control group)

From the data in Figure 2, it can be seen that the experimental group implementing the dual tutor system is significantly better than the control group in many key training and output indicators, reflecting the significant advantages of the dual tutor mechanism in practical guidance and achievement transformation. First, in terms of the proportion of students with enterprise practice time of 6 months or more, the experimental group is as high as 92%, which is much higher than the 38% of the control group, indicating that the dual tutor system can more effectively promote graduate students to participate in actual engineering projects in enterprises and enhance their application capabilities. Secondly, in terms of professional paper publication, 34 people in the experimental group have published papers, significantly more than the 22 people in the control group, showing that joint guidance from school to enterprise helps to improve students' scientific research output. In terms of paper quality, the number of students in the experimental group who wins excellent papers at the school level or above is 11, while the number of students in the control group is only 5, which further verifies the positive role of the dual tutor system in improving students' academic level. In addition, in terms of internship performance in enterprises, 29 people in the experimental group have received the evaluation of "excellent internship" from the enterprise,

which far exceeds the 8 people in the control group, reflecting that the enterprise mentors have achieved remarkable results in cultivating students' practical ability. Finally, in terms of employment signing rate, 86% of the experimental group signs employment contracts before graduation, which is significantly higher than the 64% of the control group, indicating that the dual mentor system is more conducive to improving students' employment competitiveness and career matching. Overall, the dual mentor system not only improves the academic and practical abilities of graduate students but also significantly enhances their employment orientation and performance, providing a strong guarantee for the high-quality development of graduate students.

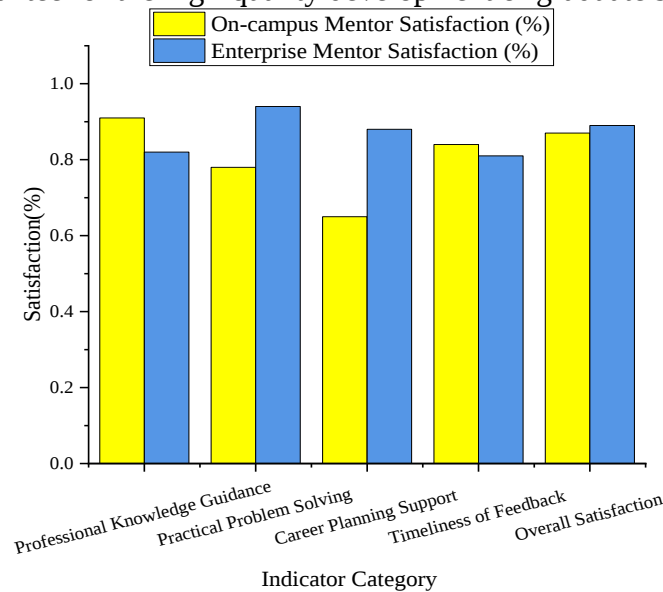


Figure 3 Satisfaction with the quality of guidance provided by on-campus and corporate mentors (student perspective, experimental group)

Judging from the results of the satisfaction survey, on-campus tutors and corporate tutors show their respective advantages and complementarity in different guidance dimensions, further verifying the synergistic effect of the dual tutor system in talent training. In terms of professional knowledge guidance, the satisfaction of on-campus tutors reaches 91%, higher than the 82% of corporate tutors, reflecting that on-campus tutors have significant advantages in theoretical knowledge imparting and academic guidance. In terms of practical problem solving and career planning support, corporate tutors perform outstandingly, with satisfaction rates of 94% and 88%, respectively, significantly higher than the 78% and 65% of on-campus tutors, indicating that corporate tutors can be closer to the actual needs of the industry, effectively help students solve practical problems and provide career development guidance (as shown in Figure 3).

5. Conclusion

This paper conducts a systematic study on the management strategy of the dual-tutor team for mechanical professional degree master's students. The paper first analyzes the main problems existing in the implementation of the dual-tutor system in current universities, including unclear division of responsibilities of tutors, insufficient frequency of guidance, and poor industry-university collaboration. Then, through questionnaire survey and experimental comparison, an empirical analysis of the ability development of graduate students under the guidance of dual tutors is conducted. The results show that scientifically constructing a dual-tutor management system and improving the frequency and quality of guidance can significantly promote the improvement of graduate students in professional ability, general ability and development ability. At

the same time, by clarifying the division of responsibilities of tutors and improving the incentive and assessment mechanism, both on-campus and off-campus tutors show higher satisfaction and cooperation enthusiasm, which effectively enhances the practical ability and employment competitiveness of graduate students. In the study, the students in the experimental group are significantly better than those in the control group in terms of enterprise practice time, academic achievement output, internship evaluation and employment signing rate, which fully reflects the positive role of the dual-tutor system in improving the quality of talent training. In addition, on-campus and off-campus tutors have their own advantages in guiding professional knowledge and career development, complementing each other, and providing more comprehensive and accurate growth support for graduate students. These findings have practical guiding significance for the reform of professional degree graduate education in universities. The differences in the dual-tutor cooperation model under different industry backgrounds have not been explored in depth. Future research can further expand the sample range, combine multi-disciplinary and cross-regional data, explore a more diversified and adaptive dual-tutor management model, and provide theoretical support and practical paths for building a high-level applied graduate education system with Chinese characteristics.

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