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Research on the Training Mode of Mechanical Engineering in Promoting Scientific Research Innovation Ability of Postgraduates

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Abstract. In the new era of China's economic construction and international development, how to improve the scientific research and innovation ability of senior talents required by enterprises is the focus of the reform of postgraduate education for engineering majors in universities at this stage. The current problems in graduate education of mechanical engineering majors of our university are analyzed in this article. With the opportunity of reform in the universities, and relying on the graduate practice teaching base of mechanical engineering discipline of Wuhan University of Science and Technology, how to explore its scientific research innovation ability promotion mechanism and scientific research innovation practice mode is discussed in the paper, then the practice base construction, a talent training model and curriculum system that improves the graduates' scientific research and innovation ability are researched, and a joint training practical teaching model between enterprises and universities is built, and guidance by dual-teacher mentors to enable high-level innovative postgraduates is realized. The training mode is gradually in line with international standards to comprehensively improve the education and teaching quality and innovative practical ability of postgraduates in mechanical engineering. The research result has important practical significance for promoting the reform and innovation of postgraduate education, promoting the new model and method of industry-university-research integration of school-enterprise cooperation, and making the mechanical engineering discipline of Wuhan University of Science and Technology to serve the economic development of Hubei Province, and the research results can be radiated to other engineering disciplines to produce a wide range of social benefits.

Keywords: Mechanical engineering, scientific research and innovation ability, postgraduate training mode, practice teaching.

1 Introduction

With China's economic construction in line with international standards, how to promote scientific and technological innovation by introducing advanced international theories and experience combining with specific domestic practices are new topics facing various fields. The foundation of technological innovation lies in higher education. Relatively speaking, there are still many deficiencies (ZHU Yan-hong, CAO Xiao-ying & LI Qun, 2019), (LU Sheng-jun & HE Min, 2019) in graduate education in China's higher education in keeping with international standards and in improving the ability of innovation. Postgraduate education in the United States emphasizes liberalization and diversification (WANG Lei, BAI Qiang & XU Zhi-man, 2019). It adopts a dual-centered teaching model centered on learning and focusing on teaching and technological innovation. It focuses on cultivating students' innovative ability, self-learning ability, and independent problem solving ability. However, China's postgraduate education (YAN Xin, LIANG Lan-ju & WEI De-quan, 2019) mainly follows the traditional teaching model centered on teaching. The task of teachers is to instill knowledge into students, the task of students is to understand, digest, and absorb the knowledge taught by teachers, the students' subjective initiative is ignored and it is difficult to fully cultivate students' scientific research and innovation ability.

As a graduate education for the cultivation of high-level specialized talents, in recent years, a large number of talents have been cultivated for the construction of an innovative country. The graduate training model of scientific research innovation ability is an important link for training high-level innovative talents, and how to build a mechanical engineering graduate training model that promotes scientific research innovation ability has important research significance.

2 Analysis of the Current Training Mode of Mechanical Engineering for Postgraduates' Education

For graduate education in mechanical engineering, its training goal is: a postgraduates should have a solid and broad basic theory and systematic in-depth expertise in this discipline, can actively broaden the knowledge, pay attention to the frontier development of disciplines and cross-application of knowledge to improve the comprehensive ability, and have the ability to conduct scientific research independently, should have the abilities of systematic and innovative, should have the capable of independently engaging in engineering design and operation, analysis and integration, research and development, management and decision-making, and should have the capable of high-level engineering technology and engineering management in the field of mechanical engineering. However, under the traditional talent training model of the mechanical engineering discipline, the graduate curriculum system and practical teaching links have restricted the cultivation of multi-level, high-quality, innovative scientific and technological talents, so it is difficult to produce innovative results after the graduate graduates, which seriously affects the scientific and technological innovation capabilities of Chinese enterprises. Its shortcomings (YAN Xin, LIANG Lan-ju & WEI De-quan, 2019), (CHEN You-liang, LI Ya-qian & FENG Jun-hua, 2019) are mainly reflected in:

(1) The postgraduate curriculum system is rigid, the teaching mode is single, the interdisciplinary and integration are not outstanding, and it lacks scientific and technological innovation and systematic foresight

Currently, the textbooks used by postgraduates in mechanical engineering are from the 1990s to 2000, compared with modern advanced technology and equipment, the textbooks are outdated and boring, it is difficult to lead students into the cultivation of innovative thinking modes in scientific research for no introducing the most advanced technologies at home and abroad. And in the context of large-scale graduate education, some deficiencies are widespread for graduate talent training of mechanical engineering disciplines such as single classroom teaching mode, consistent syllabus, unified academic system and curriculum arrangements, and failing to effectively integrate and cross-fused the mechanical engineering disciplines with the information technology, computer technology, new materials technology, engineering thermophysics, intelligent manufacturing and other disciplines. This graduate training model lacks advanced features and personalization and severely restricts the cultivation of innovative talents.

(2) It is difficult to meet the needs of industry innovation and development for insufficient scientific and technological innovation ability training in graduate practical teaching

At present, there is a general tendency to over-emphasize general education in China's graduate education. It is mainly to train students' basic theoretical knowledge supplemented by certain practical teaching, which has greatly weakened the cultivation of graduate students' scientific research innovation and practical ability. For practical mechanical engineering disciplines, if the practice fails to effectively integrate with the enterprise's advanced resources, and if it is lack of innovative practical teaching links and lack of training for innovative thinking, as a result, it is impossible to effectively combine the learned knowledge with engineering practice after employment, and it is difficult to innovate in engineering practice, which the formation of high-end R & D teams in enterprises will be affected.

So, it is of great practical significance to conduct research on the training model for mechanical engineering postgraduates' education to improve its scientific research innovative ability and to gradually integrate with international standards, and it is bound to better promote the postgraduates majoring in mechanical engineering to serve the needs of social and economic development.

3 Construction of Diversified Postgraduate's Curriculum System to Promote Its Research Innovation Ability

The guiding ideology of designing a training model for master's degree of mechanical engineering that promotes scientific research innovation ability (HUANG Ming-fu, WANG Jun-zhen & XIAO Wen-ying, 2019) is lied in some aspects such as facing the complex engineering practices, strengthening professional theoretical foundations, broadening professional knowledge, highlighting the enhancement of scientific research and innovation capabilities and the comprehensive development of science, technology and humanities, training to advanced compound technology innovation talents to meet the needs of the development of an innovative society, having excellent ideological qualities, humanities and scientific and technological innovation qualities, having a broad theoretical foundation and advanced comprehensive professional knowledge, with the ability to independently analyze and solve complex engineering problems, and having advanced self-learning ability, innovative consciousness, practical ability, and organization and coordination ability. The training goals to be achieved lie in:

(1) In course teaching, reasonable interdisciplinary curriculum system and teaching methods combining with advanced technologies in mechanical engineering are set up, and a curriculum teaching case library focusing on strengthening the cultivation of scientific research innovation ability is established.

(2) In practical teaching, a long-term training mechanism for school-enterprise cooperative training and integration of production, education and research relying on the established enterprise scientific research workstations is established, to combine theoretical teaching with innovative practice in production-learn –research.

(3) Relying on enterprise scientific research innovation practice projects and scientific research practices, some research directions with advanced research value are explored, and postgraduates are guided to research, and the innovation of the postgraduate's research dissertation is to be promoted, at the same time, it will form the future technological development direction of the enterprise and lead the enterprise to occupy the frontier of science and technology.

The development trend of mechanical disciplines is cross-disciplinary fusion (JIANG Jun & CHEN Bei-bei,2019), the basic task of its education is to apply and integrate modern scientific theories and methods such as Mechanical Science, Information Science, Materials Science, Management Science and Mathematics, Physics, Chemistry, etc. to engaged in research on complex mechanical structures and equipment, intelligent manufacturing technology and manufacturing processes, and intelligent manufacturing systems.

So, a multidisciplinary crossover and integration curriculum system relying on Hubei scientific research workstations and with the main line of the integration of production, teaching, and research is built based on the national equipment manufacturing industry policies and major needs, that emphasizes on scientific innovative (Shown in Figure 1). To adopt a diversified interactive teaching mode and combine scientific research innovation projects to cultivate scientific and technological innovative postgraduates that meet the needs of society and enterprises and better serve the development of society.

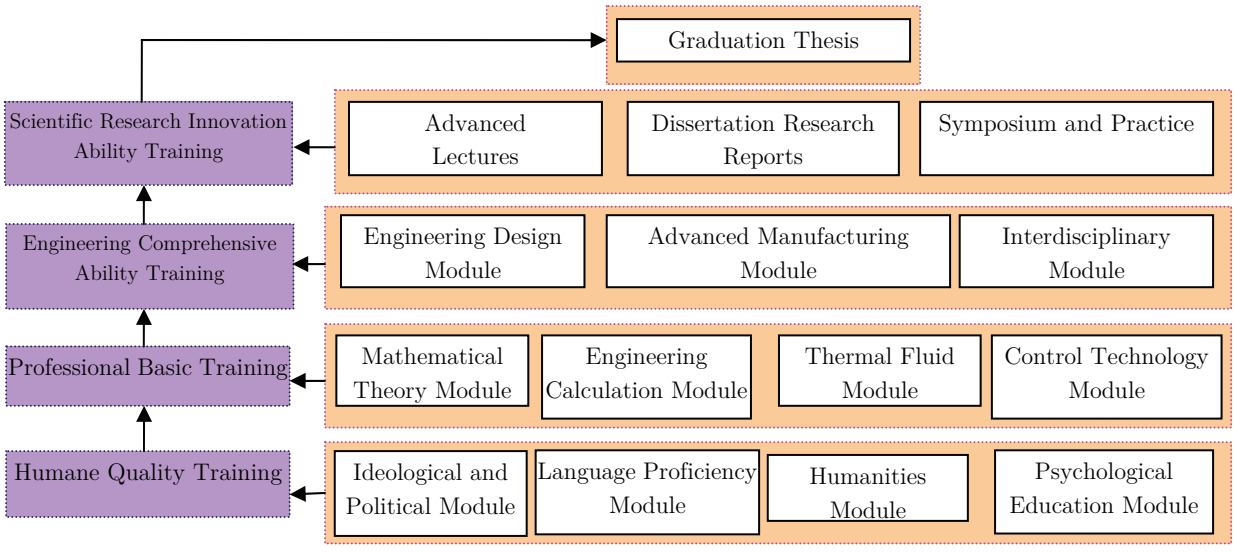

Figure 1. Course system of postgraduates majoring mechanical engineering

Combined with the postgraduate's course system shown in Figure 1, in the postgraduate's education system, at first, we attach importance to the cultivation of students' ideological and political, language ability, humanistic cultivation and psychological education in the cultivation of humanistic quality. In terms of professional basic ability training, through the study of mathematics, engineering calculations, thermal fluids, and control technologies, the basic theoretical level of interdisciplinary disciplines is cultivated to lay the foundation for later professional practice and scientific research innovation. In the engineering ability training stage, the introduction of professional design courses that intersect with engineering design, intelligent manufacturing, and disciplines interdisciplinary to cultivate students' professional ability and broaden students' cross-discipline knowledge. Finally, through the advanced lectures, special reports, professional practice, scientific research project practice to cultivate its scientific research innovation and practical ability.

In the teaching process, to strengthen the construction of the postgraduate's course teaching team, and to promote the construction of special seminar courses, research method courses, interdisciplinary courses and advanced technology courses in accordance with the requirements of innovative research for the cultivation of postgraduates, and to implement classified design, personality training, and fully mobilize postgraduates creativity, to guide and strengthen the cultivation of postgraduate's scientific research innovation ability.

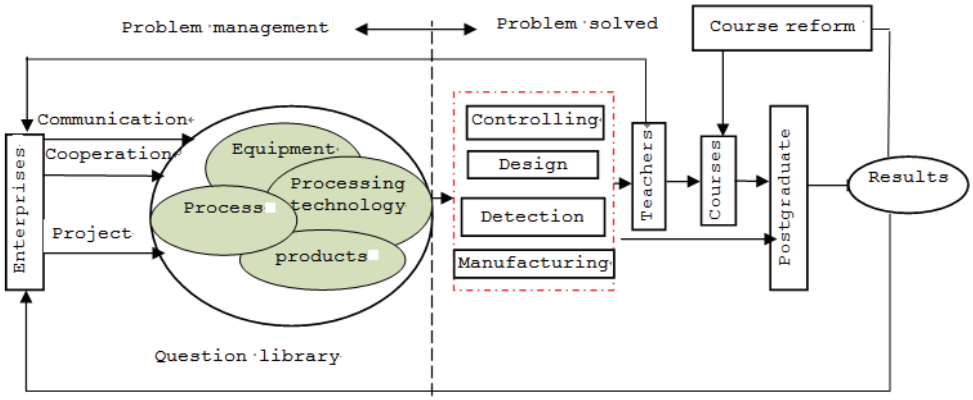

Figure 2. Project research process of postgraduates during its training

Figure 2 shows the project research process of postgraduates during its training. In the course of project research for the postgraduates, in the long-term cooperation process with enterprises for the tutor' scientific research teams, some research topics related to advanced intelligent control of electromechanical systems, advanced technology design, intelligent manufacturing, detection and fault diagnosis of complex electromechanical systems aiming at various problem libraries of the enterprise are excavated, and related professional courses are choose by postgraduates through being guided and the research topics are studied by postgraduates conducted by his tutor. In the research courses, the postgraduates communicate with the instructor and the teaching teacher to put forward the problems existing in the course learning and project practice, and to put forward the requirements for the course in scientific research innovation, and to promote the teaching teacher to reform the course, so cycle, to promote the construction of the curriculum system to be truly integrated with students' scientific research innovation, subject practice, and dissertation research, and to optimize the construction of the curriculum system.

4 Research on Postgraduates' Practical Teaching to Promote Scientific Research Innovation Ability

Mechanical engineering specialty practical teaching process is divided into course experiment, professional practice, project practice. There are some problems in the course experiment teaching: a few in-class experimental teachings are interspersed with theoretical courses, validated experiments are the main content, and there are almost no independent postgraduate's experimental courses reflected the

cultivation of scientific innovation, it is difficult to reflect the cultivation of scientific innovation, lack of planning for the construction of experimental curriculum materials and lack of experimental teaching platforms for training scientific innovation.

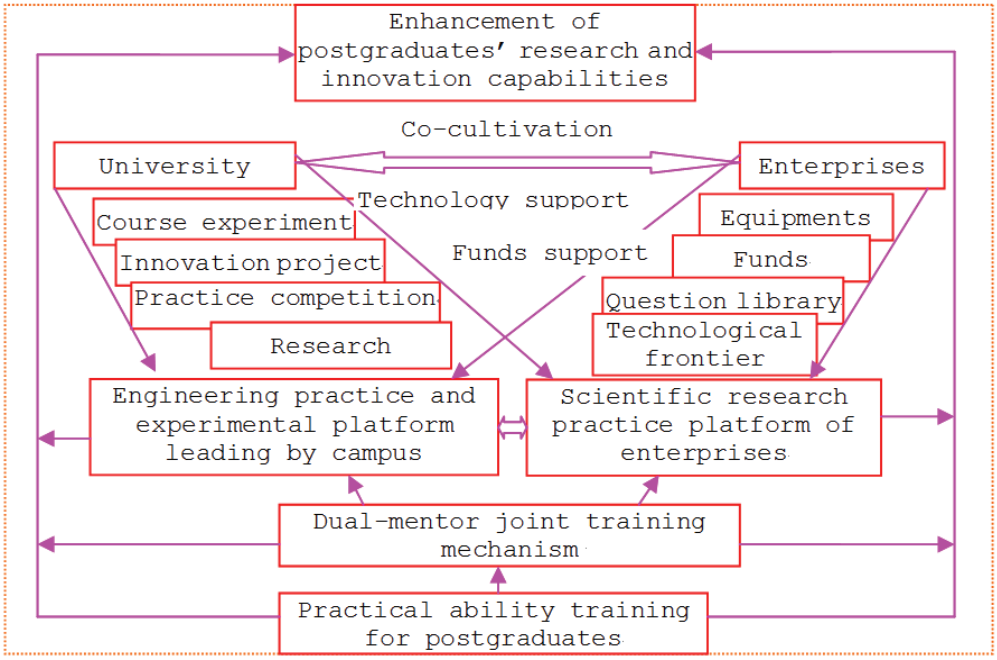

Figure 3. Postgraduate practical teaching model to promote scientific research innovation ability

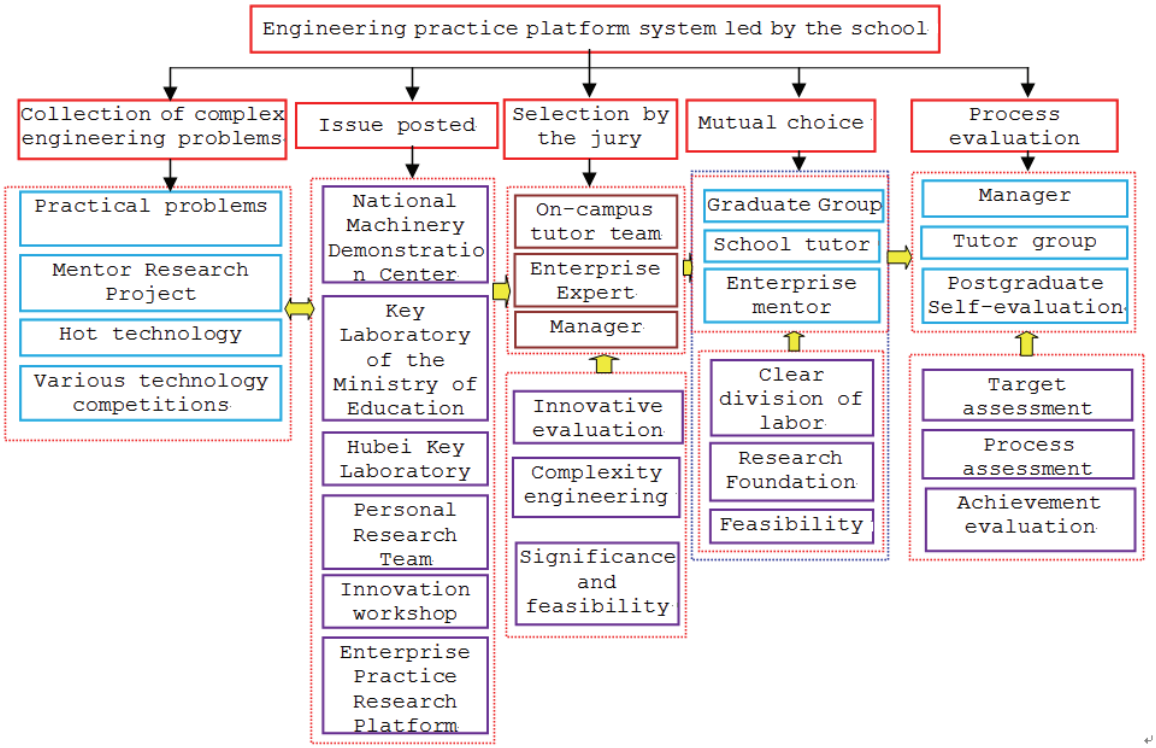

Figure 4. Construction of engineering practice platform on campus

Aiming at the problems existing in the practice teaching of postgraduates, the construction of a postgraduates' practical teaching platform to improve the scientific research innovation capabilities is needed. According to Figure 3, postgraduates' practice and innovation ability training is divided into two levels: the leading engineering practice platform on campus and joint training mechanism of dual-mentor system established by joint enterprises. In the process of scientific research cooperation between the university and enterprises, scientific research and innovation projects are found according to the needs of the enterprise. The enterprises invest technical personnel, technology, management, funds and others to jointly guide the research and innovation of postgraduates. On the one hand, the school perfects the school's engineering practice platform, at the same time, the enterprise's scientific research needs and software environment and hardware environment are incorporated into the school's engineering practice platform, and the corresponding course trials are established, then an innovative mechanism to joint train the postgraduates in schools and enterprises is formed, at the same time, the research and innovation of postgraduates will be returned to the enterprises to promote the improvement of the company's scientific and technological strength.

4.1 Construction of Experimental Courses to Promote Postgraduates' Innovation Ability

According to the practical teaching goals of postgraduates, the concept of mechanical engineering experimental course construction for postgraduate is "high starting point, innovative, industrial, professional, open and modular". The experimental courses constructed is a course that promotes the cultivation of postgraduates' scientific research innovation ability and belongs to high-level courses with high-level construction goals, which is significantly different from the corresponding courses of undergraduates. The satisfactory teaching result for postgraduates is obtained by organizing high-level profession experts and scholars to write high-level experimental lectures and to teach with high quality. At present, teachers who are motivated by scientific research are encouraged to open experimental projects in experimental courses based on their own scientific research practices, and the construction of high-level experimental courses is realized by transforming high-quality scientific research resources into high-quality teaching resources.

While emphasizing a high starting point and innovation, it often makes the course construction fall into the misunderstanding that several scientific research groups set up experimental projects individually according to their own research interests. The innovation and specialization of the experimental courses constructed should be reflected in organizing experimental content in a course rather than an arbitrary research direction. Therefore, in a field of mechanical engineering, the common creative content of this field is included in the experimental curriculum, so that students can receive comprehensive and systematic innovation training in multiple directions during the course, thereby the postgraduates' overall professional skills and literacy can be improved, and this process more well reflects the industry and professionalism of the course.

The current experimental course for improving the research and practical ability of postgraduates in mechanical engineering is comprehensive training of electromechanical systems. The content of this experimental course covers the analysis of complex mechanical systems, intelligent control and mathematical modeling of electromechanical complex systems, and various signal detection during the operation of electromechanical systems, and fault diagnosis during the operation of electromechanical systems, it basically reflects the scientific innovation of experimental courses.

4.2 Extracurricular Practice Teaching Construction to Promote Postgraduates' Scientific Research Innovation Ability

To promote the research and innovation ability of postgraduates, a diversified postgraduates' extracurricular science and technology practice systems in mechanical engineering with professional academic lectures, science and technology summer camps, challenge cup competitions, robot innovation design competitions, professional academic discussions, postgraduate's scientific and technological innovation forums, postgraduate's mathematical modeling competitions, outstanding academic paper competitions, postgraduate's innovation and entrepreneurship projects training, crane innovation design competitions (LUO Yu-lan, 2019), (CAI Gai-pin, JIANG Zhi-hong & LUO Xiao-yan, 2019) and other forms are established, at the same time, some postgraduates are attracted to participate in research

projects of different teachers, and guided by corporate engineering needs, a scientific research achievement transformation mechanism is established, and a good campus science and technology innovation atmosphere is created.

4.3 Construction of Experimental and Practical Bases to Improve Scientific Research Innovation and Practical Ability of Postgraduates

Constructing a postgraduate scientific and technological innovation experimental practice base with disciplinary characteristics and continuous innovation based on the improvement of engineering practice and innovation capabilities (ZHANG Hui-yun, ZHANG Xiao & LIU Shan-de,2019), (WU Xiao-lin, ZENG Jian-hui & YUE Da-li, 2019) is the carrier of postgraduate's scientific and technological innovation practice. At present, relying on the postgraduates' research workstations of Wuhan University of Science and Technology established in Xiangfan, Dongguan, Yangzhou, Foshan and other places, a professional practice innovation teaching platform for postgraduate's courses has been established, and some corresponding characteristic experimental instruments and equipment have been developed, and a multi-layered practice teaching system combining curriculum practice, comprehensive practice, innovative practice and social practice is been formed, and an innovative postgraduate's training mode driven by a problem-oriented approach and combining theory with practice that meets the needs of society and enterprises is formed.

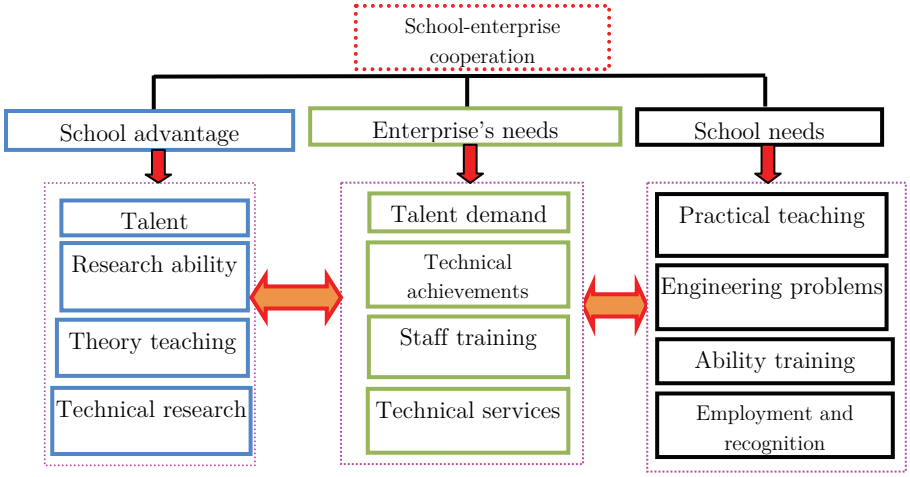

Figure 5. A practical teaching model for postgraduates constructed by school-enterprise joint

The establishment of an effective school-enterprise cooperation model is to strengthen scientific research cooperation with enterprises (Figure 5). Relying on the advantages of its own theory, scientific research, information and talents, the school has strengthened ties with enterprises to actively carry out technical cooperation and technical research. It not only solves technical problems for enterprises, but also finds a development path for schools to promote scientific and technological innovation for postgraduates by strengthening scientific and technological cooperation with the enterprises.

Relying on the scientific research results of the corporate practice base and combining corporate scientific research practices, the latest theories and research results and trends of the mechanical disciplines are enriched into the curriculum teaching and project research, the existing curriculum training programs are further adjusted and optimized, and classroom teaching of scientific and technological frontier information are further enriched, then the cultivation of scientific research and innovation interest and the enhancement of scientific research and innovation capabilities of the postgraduates are promoted.

4.4 Cultivation for Practical Guidance Teachers to Promote Postgraduates' Scientific Research Innovation Ability

The construction of scientific research innovation practice guidance teacher team is carried out from two

aspects: On the one hand, young teachers are sent to the production front line of enterprise for practical training and project cooperation to improve their scientific research and practical ability. On the other hand, enterprise senior engineering and technical personnel with rich practical experience will be hired by the school to help guide the research and innovation practice of postgraduates, and a system of "guidance and deep participation of enterprises in the cultivation process of postgraduates" is formed.

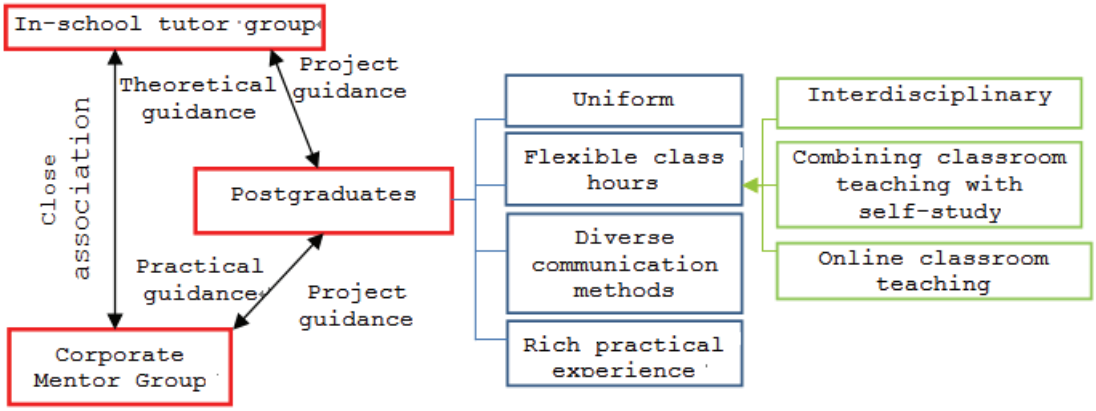

Figure 6. Dual-tutor training system

Figure 6 is a dual-tutor training system, postgraduates' science and technology innovation practice instructors must have profound theoretical knowledge and rich engineering practice experience, they can combine theoretical knowledge and engineering practice in scientific research innovation activities to guide postgraduares to carry out scientific research innovation.

5 Conclusions

The improvement of scientific research innovation ability of mechanical engineering postgraduates is a long-term systems engineering, how to meet the needs of socio-economic development for scientific and technological talents cultivated by schools is an important subject that every educators engaged in higher education must think and research at all times. The reform and exploration of the improvement mechanism of scientific research innovation ability and the realization of scientific research innovation practice of postgraduates in mechanical engineering majors of our university reflect the reform trend of scientific research innovation education of postgraduates in China. The study takes advantage of the reform opportunities of the Hubei Provincial Pilot College and relies on the postgraduates' practice teaching base of Wuhan University of Science and Technology, a talent training model that combines production, education, and research to improve postgraduates' scientific research innovation capabilities is studied and implemented, and to make the high-level innovative postgraduates' training model gradually be in line with international standards, then the education and teaching quality and innovative practical ability of postgraduates in mechanical engineering are comprehensively improved. The research results have important practical significance for promoting postgraduates' education reform and innovation, which have important practical significance for optimizing the operation and management mechanism (scientific and effective information docking mechanism, scientific research cooperation mechanism, joint training mechanism and operation management methods, etc.) of the practice base and promoting the new model of industry-university-research integration of school-enterprise cooperation, and which have important practical significance for serving the economic and social development of Hubei Province for the mechanical engineering discipline of Wuhan University of Science and Technology. The research results can be radiated to other engineering disciplines to produce demonstration and promotion effects, and then it will has a wide range of social benefits.

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Conflicts of interest. The authors declare no conflict of interest.

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