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University-industry Partnerships for Enhancing the Workplace Readiness of Professional Masters in Engineering: A Comparative Case Study in China

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Abstract

To prepare students for the engineering profession, most Chinese universities require Professional Master's students in engineering to complete "practical studies" in a real world professional context. With the recent expansion of enrollments in professional master's degree programs, universities in China face urgent needs to develop high-quality partnerships with the industry, in order to provide joint training experiences for the students. A variety of practices have been experimented between universities and industrial partners in China. This paper compares two case studies for the development of university-industry partnerships in enhancing professional masters' workplace readiness in China, each of which exemplifies a major approach in organizing the practical studies for professional master's students in engineering: The first case examines a "practice base," a broker institution that connects students to companies that are committed to the educational objectives determined by the participating universities. In the second case, the university provides a list of options for practical studies, each linked to a partner company, for students to choose.

This paper adopts the double case study method, focuses on how universities and partnering institutions negotiate common interests and ensure the sustainability of the partnerships through practices of matching students to projects, articulating rights and obligations, and monitoring and regulating risk factors. The paper also assesses the respective strengths and limitations of each of the two approaches of partnerships. This paper also studies the applicable situations of the two cooperation modes.

Based on the comparative case study, this paper summarizes the key success factors for effective partnerships between Chinese universities and companies in preparing professional master's students for the workplace: (1) shared understanding of the educational functions of practice studies; (2) clear deliverables; (3) stability of practice duration; and (4) flexibility in connecting students to projects.

1. Introduction

With the development of science and technology, the demand for high-end applied technical personnel is increasing. Institutions in many countries offer professional or vocational degrees at the level of graduate education to cultivate higher level of applied engineering talents, and the scale of students in engineering professional degree is expanding year by year. In view of the original intention of the establishment of professional master's degree in engineering, the training goal is oriented to the competence in engineering practice. How to make students successfully transition from school to workplace is an issue that engineering educators across the world are exploring.

China, which has the largest engineering education in the world, has been exploring professional engineering degrees for more than 20 years. According to the Education Development Plan for Graduate Students of Professional Degrees (2020-2025) issued by the Academic Degrees Committee of The State Council and the Ministry of Education, the orientation of professional master's degrees is to cultivate application-oriented specialized talents, and the integration of industry and universities in the construction of joint training bases is taken as an

important condition for institutions seeking professional master's degree authorization. According to the policy documents, training units shall jointly formulate training plans together with industries and carry out the construction of joint training bases. [1]One of the characteristics of the admission of full-time engineering masters degree in China is that most of the students enrolled have no prior work experience. The training of engineering masters in China is oriented towards vocational demand and engineering ability. Under this background, how to improve students' workplace readiness through practical training during the school period is an important issue. This comparative analysis focuses on how universities and partner institutions in the industry negotiate mutual benefits, how students are matched to engineering projects, what means should be used to ensure the quality of joint cultivation, and how risk factors are monitored and adjusted to ensure the sustainability of university-industry partnerships.

Direct connection between universities and companies, as well as the existence of third-party platforms are two widely used models at present in China[2]. In both modes, students complete training sessions in real world engineering environment outside the universities. In the first mode of cooperation, universities use their previous cooperation basis to directly cooperate with the industrial practice bases for jointly cultivation. While in the second cooperation mode, the third-party platform integrates the demands of universities and companies to build a matching bridge between the two parties. In this paper, two cases from China are selected to explore the corporation under the two modes. The integration between university and industry to cultivate professional degree students in engineering is reflected in the key parts in the process of talent training, such as tutor guidance, course teaching, practical learning, graduation examination, vocational certification and so on[3]. Through field research in the practice bases and interviews with the parties involved in jointly cultivation, we found that the two cooperation modes have achieved relatively satisfactory results in practice. On this basis, this paper focuses on the characteristics of the two modes of joint cultivation, compares the similarities and differences between the two modes, and explores the application conditions of the two modes. The key elements of effective and long-term cooperative relationships are further explored through the comparison of commonness, so that educational institutions can choose to adapt the joint training mode suitable for the local contexts. With the further improvement of the quality requirements of engineering education, this study provides a reference for the good match between students and engineering projects. With the further expansion of the enrollment scale of professional master students, the research of this paper has implications for a broader range of engineering education institutions. In particular, given that China has a large number of engineering students, the experience of providing enough engineering projects for students and matching students to the appropriate projects can be a good reference for other countries in engineering education.

2. Literature Review

As early as 1906, the University of Cincinnati launched cooperative education program, a paid internship in which universities and enterprises cooperate to train students. This model has since been emulated in many countries, which is an early model of modern education integrating

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[1] http://wap.moe.gov.cn/jyb_xwfb/s5147/202010/t20201009_493536.html

[2] Yi Ran, Shen Yan, Yang Bin&Zhang Shulin (2017). Deepen the comprehensive reform of graduate education for engineering majors Degree and postgraduate education (01), 5-7.

[3] Ma Yonghong, Liu Runze, Yu Miaomiao. The Connotation, type and Development of Professional Degree Students in China [J]. Degree and Graduate Education,2021,No.344(07):12-18.

industry and education[4]. In modern times, various countries have begun to explore the deep integration forms between industry and education. For example, Germany's "dual system" of vocational education, in which private enterprises are regarded as one party and schools run by the state are regarded as another party, is a cooperative vocational education system of training skilled talents. Although Germany has not yet carried out the exploration of modern apprenticeship at the postgraduate level, the United States, Britain and France have begun to explore the type of professional degree with deep integration of industry and education represented by apprenticeship.. By exploring deep integration of industry and education and seeking ways of connecting educational achievements and vocational qualifications, the overall development of education and industry has been promoted[5].

With the needs of economic and social development, applied knowledge gradually infiltrates into the field of postgraduate education, and "non-academic degree" independent of academic degree gradually appears. In terms of the research on the concept, the academic degree and non-academic degree are generally recognized by the academic circle, but different countries have different classifications and names. According to the *Classification of Instructional Programs* published by National Center for Education Statistics, the American degree system can be divided into three categories: academic degree, applied and professional degree(such as MBA or Ed.D), and vocational degree (such as first vocational degree FPD)[6]. In China, the classifications are mainly academic degrees and professional degrees. In terms of the research on connotation, some scholars have explored the difference between the training objectives of professional degree and academic degree in engineering. Different from academic degrees, which emphasize advanced knowledge and top-notch research, professional degrees attach more importance to the close connection with engineering practice[7]. The professional degree is a kind of degree that takes Into account academic, career-oriented and practical elements of training. From the perspective of knowledge production mode, the knowledge production of academic degree is more centered on disciplines and universities, that is, it is adapted to the traditional knowledge production mode I. In contrast, the knowledge production of professional degree is based on the application situation, with interdisciplinary nature and emphasis on the application value and social role of research, taking into account the characteristics of knowledge production mode I and II[89]. As for the research on the training objectives of engineering professional degree graduates, the understanding of different scholars converge on highlighting engineering practical ability as the key ability of graduates, which is also the trend of global engineering education reform. On how to cultivate engineering practical ability, scholars have carried out research from theory and practice, such as knowledge production theory, situational learning theory, triple helix theory. In addition, there is

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[5] Ma Yonghong, Zhang Feilong. International trend and enlightenment of graduate education development of professional degree [J]. Journal of Beijing University of Aeronautics and Astronautics (Social Science Edition),2021,34(03):142-150.

[6] National Center for Education Statistics.Classification of instructional programs-2020[EB/OL].(2019-03-20)[2023-02-01].https://nces.ed.gov/pubsearch.

[7] MICHAEL J. Contemporary trends in professional doctorates[J]. Studies in higher education, 2018, 43(5):814-825.

[8] GIBBONS M, LIMOGES C, NOWOTNY H, et al. The new production of knowledge:the dynamics of science and research in contemporary societies[M]. London:Sage Publications, 1994:2-7.

[9] BRUUN H, LANGLAIS R, RASK M, et al. Moving to mode2:remodeling research education in university departments[J].International journal of learning and change, 2005, 1(1):46-65.

project-based learning[10][11], the stakeholder theory involving industry and education cooperation participants, and the CDIO model which integrates concepts of learning by doing", "unity of knowledge and practice", "project teaching" and "integration of truth and reality"[12]. There are also scholars who study from the perspective of problem finding and solving in practice. For example, some scholars have pointed out that there are some problems in China's engineering master education, such as the low orientation of professional degree personnel training[13], the simplification and formalization of practical training links[14], as well as the lack of convergence between training process and academic degree graduates[15], who cannot meet the objective needs of economic and social development in the macro training objectives. Generally speaking, the cultivation of engineering practical ability and the cooperation between industry and university are very important for professional master students in engineering. However, most current research focuses on off-campus practice as an unified strategy for cultivating students' practical competency and inadequately attends to the heterogeneity within this realm of training. The existing literature also ignores the differences of students' participation forms in engineering practice under different cooperation modes between industry and education.

3. Research Design

3.1 Rationale for method choice

This study uses the comparative case study method. There are three reasons for choosing this method. First, the research question is suitable to adopt the case study method. At present, the practice training of full-time engineering masters in China is still in the exploratory stage. With the further increase of the enrollment scale of engineering masters, it is urgent to explore the effective university-industry partnership to provide enough and suitable projects for students. However, the existing theoretical and empirical studies have limited understanding of this problem. The purpose of this paper is to answer the question of how to strengthen the workplace readiness of engineering masters in the jointly cultivation partnership between universities and industries. Case studies can provide an in-depth analysis of the typical individuals, helping to understand the process mechanism behind the phenomenon[16], and is suitable for answering the "how" and "why" questions in under-explored fields.[17][18]

Secondly, this paper aims to explore different modes of university-industry partnerships to strengthen engineering masters' workplace readiness. It is suitable to use the multi-case study

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method to construct theories. The multi-case study method has the advantages of constructing and testing new theories, and can achieve the research objectives of this research.[19]

Third, based on the characteristics of the research objects, this paper adopts the mutually reinforcing double case study method. There are obvious differences in the cooperation modes of the two selected cases, which make it possible to explore the advantages and disadvantages of different modes. Mutually reinforcing double case studies can confirm and supplement each other on the same issue.[20, 21]By comparing similarities and differences, this paper attempts to explore the core elements of an effective university-industry partnership and discusses their application situation.

3.2Case selection

Following the principle of typicality and theoretical sampling, this paper chooses two case that represent, respectively, third-party platform and direct cooperation between universities and practice bases. The first case is Guangdong Shunde Industrial Design and Research Institute located in Shunde District, Foshan City, Guangdong Province, China(hereinafter referred to as "Lianchuang"); Another example is Tsinghua University's model of direct cooperation with enterprises.

One of the purposes of this study is to study different modes of cooperation. The two cases selected have their own characteristics and are also typical in terms of off-campus practice education. Lianchuang is the only institution that has been awarded "National Engineering Graduate Joint Training Open Base" by the National Engineering Graduate Education Steering Committee, and the only third-party platform model that has been certified in China. On the other hand, as the top engineering university in China， Tsinghua University has a solid foundation in industry-university-research cooperation, and its directly cooperative off-campus joint training bases have obvious advantages in quantity and quality. These differences provide an opportunity to explore different university-industry cooperative education models. Moreover, given that a more fundamental purpose of this study is to explore effective university-industry cooperation relationship, it is necessary to build on the sample that has achieved positive results. Lianchuang has rich experience in the joint training of professional masters in engineering, which will be described in detail in the following sections. As a first-class engineering university in China, Tsinghua University has accumulated many years in the cultivation of engineering masters through school-enterprise cooperation, and is also one of the first universities in China to offer professional degree in engineering. The two cooperation modes are similar in terms of participants and organizational forms, and have a certain degree of comparability. Both cooperation modes focus on the off-campus practice of full-time professional masters in engineering, and in the two selected cases, students are required to complete at least half a year of off-campus engineering practice to meet graduation requirements. To sum up, the two cases selected are appropriate samples for answering the research questions of this paper.

3.3Data collection and analysis

This study adopted participatory observation, semi-structured interview, and archival

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research for collecting case data. We also attempted to ensure the authenticity and reliability of the data by supplementing and triangulating the information from diverse sources. From July to August 2022, the first author conducted six weeks of participatory observation in Lianchuang, Shunde District, Foshan City, Guangdong Province. During this period, the first author worked in the same office with jointly cultivated students, and had the opportunity to observe the actual daily situation of the co-cultivated students in depth. What is more, daily interaction with co-trained students is also an important source of information. Interviews were conducted with relevant academic affairs teachers in Lianchuang, university advisors, co-cultivated students, and company advisors. Over 20 formal interviews were conducted for this study. In addition, archival research was conducted to acquire and analyze official materials and internal information. Official materials include publicized documents from WeChat public accounts owned by relevant institutions; internal materials include description of research content, postgraduate management regulations, training system regulations (e.g., "Postgraduate Joint Training Manual"), statistics of thesiss in joint training bases, etc. Additional documents include lists of joint training requirements, internal meeting minutes, research results documents, student completion training report materials, etc. Based on multi-level and multi-source data collection, triangulation is carried out to provide a richer and more reliable analysis for the cultivation mode of university-industry cooperation practice.

In this paper, the two cases are coded separately. Firstly, the initial data are conceptualized and labeled to construct a first-order concept. Then the first-order concept is further coded, the second-order theme is formed after induction and labeling of the first-order concept, and the relationship between concepts is established through classification, so as to further discover the nature and level of concepts. Finally, the first order concepts and second order themes of the two cases are iterated and checked, and the new aggregation concepts are further summarized by comparing the relationship between various themes.

4. Cases

4.1Lianchuang

Founded in 2014, Guangdong Shunde Innovation Design and Research Institute is a public institution directly under Shunde District, Foshan City, Guangdong Province. Its core business is postgraduate joint training, innovation and entrepreneurship incubation, and enterprise science and technology services. Its main research fields include precision instrument research and development, information technology, mechanical automation, industrial design, etc. Shunde District, where Lianchuang is located, is an important part of the Guangdong-Hong Kong-Macao Greater Bay Area and one of the world's most influential advanced manufacturing bases. The joint training students usually go through three stages: in universities, in enterprise or project team, and back to universities. In the first stage, according to the requirements of the training plan, the graduate students finish the basic courses in their universities and make their proposal reports. The second stage is practical training, which includes quality courses, vocational courses, customized professional courses and project practice. The training of full-time professional master students in engineering will be completed in Lianchuang and local enterprises in Shunde District. In the third stage, based on the work in the practice bases, students return to universities for the thesis defense.

(1) Project matching

Lianchuang provides a considerable number of engineering projects for the co-cultivated

students. The engineering projects for the students to participate mainly come from two channels. One is the R&D projects launched by Lianchuang. In order to improve the quality of co-cultivation, Lianchuang has set up quality-oriented cultural activity courses, project-leading courses and project-supplementary courses to help students get ready for in-depth engineering practice. The second is research projects from local partnering enterprises. Lianchuang regularly collects the demands of local enterprises and forms a list of demands after coordinating with enterprises. Through bidirectional selection, the engineering projects of enterprises are matched with students. According to the data provided by Lianchuang, more than 340 enterprises have participated in joint training, and 1,200 joint training projects for postgraduates have been collected so far, with more than 4,000 job demands. For local enterprises, they can put forward their needs for students according to their own situations, and the positions and requirements for each demand are not fixed, so they have great flexibility. Notably, Lianchuang does not exclude small companies from participating in these joint partnerships.

(2) Balance of interests

The character of Lianchuang is a public institution, the main source of funding is Foshan Education Bureau. "One of the government's assessment indicators for us is the introduction of resources, including talent factors and technical resources." An interviewee from Dean's Office said when referring to the assessment of Lianchuang by higher authorities. For Lianchuang, the more students it attracts, the more fund it can receive from the local education bureau. In interviews with the teaching affairs and practice advisors of Lianchuang, some interviewees mentioned that "we can also give students the opportunity to try and innovate through projects with low probability of success, or projects that have failed in the past. This allows for the educational function of these projects." Local government encourages students to come to Lianchuang for joint training through talent subsidies and other means, because students and their universities can bring talent resources to Shunde District and make contributions to local enterprises. Faculty from cooperative universities seek potential research cooperation with Lianchuang or publicly funded research projects cooperation with local enterprises through Lianchuang by sending joint cultivated students. University faculty also discover potential collaboration opportunities through feedback from co-cultivated students. Because the universities Lianchuang cooperates with are not all elite universities in China, and acquiring research funds can be challenging, sending students to seek cooperation opens new avenues for research funding. At the beginning of its establishment, Lianchuang took the initiative to seek training cooperation from universities. Lianchuang not only helps universities solve the problem of inadequate practical projects, but also reduces the cost of developing partnerships. For students, participating in cutting-edge and actual projects through this third-party platform like Lianchuang can also be beneficial to their future job hunting. Some interviewed students mentioned that "with the experience of participating in the projects, it is more competitive to get a job." It can be seen that government departments, Lianchuang, universities and students all recognize the importance and benefits of joint training and have the motivation to participate in it.

(3) Quality assurance

First, the guidance to the students is systematic in Lianchuang. The "double tutorial system" is implemented, in which students maintain communication with project advisors and university advisors, so that their work are both practical and academic. The teaching and curriculum of Lianchuang are organized around engineering projects. The combination of theoretical teaching in

universities, innovative practical ability training, and enterprise project training forms a systematic innovative practical ability training system for jointly cultivated students. In addition, Lianchuang offers local culture-related courses to its students so that they can adapt to local life as soon as possible. Second, the management of joint training is institutionalized. Lianchuang has a clear management system for advisors and students, such as the selection criteria for outstanding joint training graduate students, issuing criteria for joint training certificate for graduate students, codes of conduct for graduate students, etc. The third is to strengthen the cultivation of the bottom-line control. For students who have been jointly trained for more than one year, after admission to the graduate school, the student's department and the jointly training enterprise shall jointly negotiate to develop a joint training plan for the graduate students and select the research topic of the master's thesis. During the joint training period, the student's on-campus and off-campus advisors are to conduct process management and guidance on the practice-based thesis.

(4) Risk control

First, the research content is flexible. When students enter the projects, they are in the mode of apprenticeship. Students are mostly engaged in theoretical research, and most of the R&D projects that students are engaged in are extendable. This arrangement ensures that the impact of students' entry time on the project cycle is not significant. The second is to control the bottom-line of the output of joint cultivation. Master's thesis is the most important bottom-line for student participants. For students who have a longer training period, especially those whose graduation thesis is based on the project during the joint training period, Lianchuang will prioritize student needs over its own research projects. In case the projects stop or change obviously with the expectation due to business risk or business adjustment of the joint training enterprises, which leads to the major risk that the student cannot carry out the graduation thesis work according to the original plans, Lianchuang can take students back to its own R&D projects to support students' s thesis research.

4.2Tsinghua University

In 1984, Tsinghua University and 11 other Chinese universities jointly advocated the training of professional master's students in engineering, which became the prelude to the exploration and development of engineering master's education. As one of the first pilot institutions, Tsinghua University officially recruited professional engineering master's students in 1996, and began to pilot full-time professional engineering master's students training in 2009. The scientific research management department of Tsinghua University regularly formulates work plans to develop scientific and technological cooperation with key enterprises and regions, and strives to make every discipline or department of the university have a counterpart leading cooperative enterprise. At present, the main disciplines of Tsinghua University have basically established cooperative relations with leading enterprises in the industry[22].Tsinghua University has rich accumulation in engineering projects and practice bases cooperation, and its full-time engineering master's training adopts direct cooperation mode, that is, Tsinghua University directly cooperates with practice bases, and directly sends students to enterprises for cooperation training.

（1） Project matching

Based on the cooperation foundation of Tsinghua University, the practical training of full-time professional engineering master's students is mainly initiated through the contact

[22] Chen Xialing, Zhang Hu. Practical research on Industry-University-Research Cooperation Promoting Academic Development -- A Case study of Tsinghua University [J]. Science and Technology of Chinese Universities,2020,No.380(04):7-10.

between faculty members and enterprises as well as project cooperation communication. The student practice bases are usually the units that have project cooperation with advisors in the university, and joint training projects are usually done by both the universities and cooperative enterprises. Faculty or practice units often introduce projects to students in the form of information sessions, giving students a list of materials, organizing company visits and so on. Students can choose projects through the recommendation of advisors or through registering in a matching system by themselves. For example, in the document sent to students by a practice unit, it explains in detail the source departments of the subjects, the names of the thesis subjects, the specific research contents of the subjects, the results to be achieved, the conditions to be met by the students, and the number of students to be admitted. In order to ensure the two-way understanding and matching between students and the projects, it is stipulated in the requirements for students:

1. Familiar with traffic simulation is preferred;

2. Strong ability to work under pressure, flexible thinking, strong communication skills and expression skills;

3. Have enough research spirit, awe of technology;

4. Must comply with the company's attendance system, obey the arrangement of the company's responsible person.

Detailed description of the project is conducive to enhancing students' understanding of the projects. Because the characteristics of the joint training units are based on the original cooperation basis, the students are mostly trained in scientific research institutions and large enterprises, which have good education background in terms of teachers, hardware equipment and cooperation experience.

(2) Balance of interests

After the joint training begins, the students will directly enter the enterprises as interns in the their joint training enterprises, and they will be managed according to the internship system, such as daily attendance, and receive the intern allowance. The difference between students and interns is the intensity of training, and the joint training has higher requirements for students' output. For example, the required deliverables of a jointly training project are:

1. Literature review of traffic emission calculation theory;

2. Emission calculation algorithm model;

3. Research report on vehicle emission and carbon emission from traffic mobile sources.

Students can choose projects with different requirements according to their preferences, which satisfies their personal and professional development needs. However, there is also the problem of personal choice being interfered by the advisors. For example, a student mentioned in an interview that "we usually go to the advisor's own company, but we do not resist it". For joint training units, the comprehensive quality of students from famous universities is generally higher, especially for Tsinghua University, which is the top university of engineering in China. Enterprises can reduce the cost of intern recruitment and the difficulty of intern management through centralized recruitment. An enterprise advisor mentioned in an interview that "because of the different cultures of different schools, the styles of students from different schools are very different". Especially for the relatively long-term partners, both universities and enterprises can reduce the cost of communication and increase the depth of cooperation through relatively continuous cooperative relations.

(3) Quality assurance

Strengthening process evaluation is one of the central means to ensure the quality of joint training. Especially in the projects of direct cooperation with the faculty members, students will keep close communication with their university advisors during the joint training period. Some of the joint training programs adopt elimination system, and students can receive credits only if they pass the midterm and final defenses. Another important measure for quality assurance is clear delivery-oriented approaches. The companies participating in the joint cultivation will clearly present the deliverables of the projects when they release the project information. Some of the joint training topics can be used as students' graduation thesis topics. If there are more than one student participating in the same topic, then the subdivision direction will be considered as part of the graduation thesis, and not repeated with other students. Several interviewed students said: "Joint training will produce better results, which will be helpful in finding jobs later." Clear deliverable requirements or projects as part of the thesis research can effectively motivate students.

(4) Risk control

The companies cooperating with Tsinghua University usually have relatively strong positions in their respective industries and good educational conditions, such as more advanced equipment, more excellent enterprise advisors and more cutting-edge projects. Therefore, the cooperation based on previous cooperation can further reduce the risk at the entrance. However, this kind of jointly training cooperation based on previous scientific research cooperation also has the risk of deviating from educational orientation, and the inertia of scientific research orientation may weaken the educational function, especially in enriching students' training in engineering practice. How to make the training units put the education function in the core position of cooperation through communication is a question that universities must consider.

5. Implication

5.1 Reasons for choosing two modes of cooperation

Why do universities choose the third party or direct cooperation as two different dispatch modes? One reason is to break the constraints of geographical proximity. Geographic proximity helps build cooperative networks between different types of organizations[23]. Scholars represented by Allen[24] and Deeds[25] believe that geographical proximity between enterprises and universities is conducive to the formation of formal and informal networks, thus promoting cooperative innovation between enterprises and universities. According to the statistical analysis of the outstanding cases of industry-university-research cooperation nationwide, Chinese scholars have found that the geographical proximity effect is obvious in the cooperative innovation between Chinese enterprises and universities[26]. Located in Shunde District, as an important part of the Guangdong-Hong Kong-Macao Greater Bay Area, Lianchuang is the world's most influential

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[25] Deeds D L, Decarolis D, Coombs J.Dynamic capabilities and new product development in high technology ventures:An empirical analysis of new biotechnology firms[J].Journal of Business Venturing, 2000, 15 (3) :211-229.

[26] Li Lin, Zheng Gang & Yang Jun. (2012). The effect of geographical proximity in China's industry-university-research cooperation innovation: Based on the statistical analysis of outstanding cases. Industrial Technology and Economics (09),28-34.

advanced manufacturing base and modern service industry. Shunde District has been approved to take the lead in the construction of Guangdong Province's high-quality development mechanism system reform and innovation experimental zone. It has a good foundation in the transformation of engineering and technological achievements, and the project opportunities greatly attract industry-university cooperation from universities in other regions. Another reason is that universities with varying reputations and influences might make strategic choices to strengthen their partnership with other sectors. Universities with high reputation and influence tend to have more and higher quality engineering cooperation projects, and students have more opportunities to choose engineering projects that are more relevant to their majors. Tsinghua University has the relatively solid foundation of industry-university cooperation, its high-quality students are also favored by enterprises. However, universities with moderate influence in the industry do not have enough cooperative relationships to support the joint training of professional engineering master's students, so the third-party platform can effectively alleviate the problem of projects supply shortage. According to the cluster analysis of Lianchuang's cooperative universities, it is found that most of the partner universities ranked relatively low in China, and the previous cooperative relationships cannot meet the practice bases demand of professional engineering master's students. In this case, Lianchuang effectively matches the needs of universities and enterprises.

5.2 Comparison of two cooperation modes

The two cooperative modes have a lot in common, and both can provide students with more project opportunities. From the perspective of leadership, the cooperation of third-party platforms is dominated by Lianchuang. In the assessment of Lianchuang by higher-level units, talent attraction and transformation of scientific and technological achievements occupy a large position. Therefore, Lianchuang does not passively wait for the cooperation of universities, but actively seeks cooperation with universities.

In terms of project matching, in the mode of direct cooperation between universities and enterprises, especially in the cooperation projects with university advisors, faculty and students have more information about engineering projects, and enterprises also have a general estimation of students' ability level. However, university advisors prefer to send students first to the projects they are working on, which limits students' freedom of choice to some extent. In the cooperation mode of the third-party platform, the demand of the enterprises may not completely fit students' majors, and the engineering projects that the student participates in may have some distance from their majors, which requires higher cross-disciplinary abilities. To address the issue of adaptation, Lianchuang provides project-focused curriculum to improve students' cross-disciplinary skills and help them become competent.

In terms of organizational functions, the third-party platform shares the function of university-enterprise connection, and also assumes the function of student training management to a certain extent. For example, Lianchuang plays the function of student housing management when the enterprise cannot arrange students accommodation, and has formal regulations on the management of postgraduate dormitory. The teaching staff of Lianchuang regularly communicate with the students cultivated in enterprises about their work tasks, and participate in the presentation of the students' final work.

In terms of the collaboration of participants, the enterprises that directly cooperate with universities tend to have a large scale, high consistency between research content and students' majors, and low transfer cost of students. In the third-party platform cooperation mode, the

platform plays a role in connecting the needs of parties. The source of education risks not only comes from the cooperative enterprises, but also has a lot to do with the operation mode of the platform. Compared with the mode of direct cooperation, when Lianchuang collects the engineering project requirements of local enterprises, the enterprises or projects registered are not the same each time, and the education foundation of different enterprises is uneven, so it is difficult to ensure that each project has sufficient education conditions, which increases the risk to a certain extent.

Table 1 Comparison of Two Cooperation Modes

	Third-party platform	Self-developing cooperation
Project supply	Large quantity	High quality
Project allocation	More choices	More appropriate
Student transfer cost	Higher	Lower
Freedom of choice	More	Less
University influence	Modest	Higher
Cooperative enterprise	Larger quantity	Higher quality
Dominant force	Third-party platform	Universities or enterprises
Mutual understanding degree	Lower	Higher

5.3 Key elements of long-term and efficient cooperative relationships

First, all parties recognize the educational function of the practice projects. Lianchuang is a non-profit institution funded by the government. To some extent, it emphasizes more of its non-profit functions, with less utilitarian requirements for students' output and more recognition of the responsibility of education. The philosophy of the founding dean of Lianchuang also reflects a high sense of responsibility for education. Several educational administration staff from Lianchuang mentioned the "spiritual guidance" of its founding dean in interviews. The interest neutrality and non-profit of the third-party platform also increase the trust of universities and students, especially the certification of the National Graduate Education Committee for Professional Engineering Degree. In the direct cooperation mode, because the jointly cultivated students are equivalent to interns in the enterprise, most enterprises already have a set of management measures and intern training system. Besides, corporate social responsibility is also one of the sources of enterprise education consciousness.

The second key element for sustainable university-industry partnership is the need for clear deliverables. Students' practice needs to be results-oriented, and delivery targets need to be clearly defined before the start of training. In addition, there is a need for an agreed results system, confidentiality agreements, and reimbursement agreements, so as to avoid the risk of technology leakage and intellectual property disputes.

Third, a certain period of time needs to be guaranteed. Mentors from Lianchuang and enterprises all mentioned in the interviews that "students can't do anything worthwhile for less than three months", and "the duration should be at least half a year or a year." In practice, students can apply to extend the period of joint training. Time investment enables students to participate in engineering projects at a higher and deeper level, and to play a more central role in their teams.

Fourth, there should be flexibility in matching students with engineering projects. In the real engineering situation, it is impossible to implement the projects completely in accordance with the

expected planning, so it will inevitably be adjusted according to the actual situation. In view of the problem of students' entry time and project cycle, the two cooperation modes have solved this problem through effective measures, such as dividing projects into smaller topics, providing extendable projects, etc.

6. Conclusion

6.1 Theoretical and practical contributions

Multi-subject cooperation is the distinctive feature of the integration of production and education to train professional degree graduates[27]. At present, the research on the model of joint cultivation practice education has not adequately distinguished different cooperation models, and few scholars study the cooperation models of third-party platforms, with even less comparative research on different cooperation models. The current study has certain significance. This study explores the interest demands of all parties in two kinds of industry-university cooperation practice education in China, and attempts to summarize the common key successful elements of long-term cooperation in the two successful cooperation modes, which provides a basis for policy formulation and system design, and is of great significance for the construction of industry-university cooperation education mechanism.

In addition, this study compares the advantages, disadvantages, and applicability of the two cooperation modes. When is it more suitable for universities to choose a third-party cooperation model? First, the original cooperation basis cannot meet the demands of students, and the cooperation resources in high-quality projects are insufficient. Second, universities want to seek cooperation with industrial clusters that are geographically distant. In the face of the expansion of the enrollment scale of full-time engineering masters in China and the further increase of the requirements for engineering practice projects, third-party platforms will play a more significant role in the connection between universities and enterprises. In contrast, direct cooperation is more suitable for universities with high-quality cooperation basis. Joint training based on original cooperation can reduce negotiation costs and student conversion costs, and can reduce the risk of project collapse. With the further expansion of the scale of professional degree students in engineering, this study provides a reference for devising off-campus practice training of engineering students, and helps different schools choose the appropriate cooperation modes according to their own cooperation basis. China has the largest number of engineering students in the world, and its experience in effectively matching students to engineering projects can provide experience for the integration of industry and education in other parts of the world.

6.2 Limitations and prospects

Although this paper explores and compares the characteristics of the two modes of cooperation, there are still some limitations that need to be further explored. First of all, this paper chooses two modes of direct cooperation between universities and enterprises and third-party platforms, and only focuses on off-campus practice training modes, but there are other practice education modes that are also worthy of study. Secondly, other external factors may also have an obvious impacts on the model of practical education cooperation, such as relevant national policies and certification of joint training practice bases. Finally, it is worth studying what specific

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[27] Ministry of Education of the People's Republic of China. Notice on the issuance of *Education Development Program for Professional Degree PostGraduates (2020-2025)*[EB/OL].(2020-09-25)[2023-02-01].http://www.moe.gov.cn/srcsite/A22/moe_826/202009/t20200930_492590.html.

abilities engineering master students acquire in the joint training and how these abilities support their subsequent career development.

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