Exploration and Practice of an Innovative Idea and Method of Organized Engineering Education

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***Abstract*—This Innovate Practice Full Paper presents an innovative idea and method of organized engineering education. With the rapid globalization of China's economy, and especially the emergence of a large number of innovative large-scale enterprises supported by advanced technology, a great number of engineering-proficient talents is urgently needed. However, there is a disparity between the talent cultivation system in China and the societal demand for well-educated specialists. Every year, more than 9 million people enter various colleges and universities in China. Likewise, a large number of students graduate and enter the job market annually. Although China's higher education system has made great progress, the quality of engineering performed by graduates from various types of colleges and universities is low and remains far from meeting society's demands. Through extensive research and analysis, we have come to believe that the main reasons for this phenomenon can be summed up in two points: firstly, the system for teaching engineering needs further improvement. Engineering education is in a very fragmented state and lacks unified standards. Different colleges and universities have different understandings of engineering education, leading to the educational methods they use being inconsistently applied. Secondly, social engineering education resources are not used optimally. With this in mind, we propose an innovative and logical solution to the engineering education problems China faces. The method attaches importance to the teaching of organized courses, emphasizes the practice of organized engineering, and vigorously carries out the construction of a planned practice base. Through more than ten years of exploration and practice, we have made a series of achievements and gained a wealth of experience, opening up a road for China's engineering education. We hope that our research can contribute to the organized and uniform development of engineering education around the world.**

Keywords — organized engineering education, Master of Engineering, practical education base, cultural construction

I. INTRODUCTION

Engineering education is an important sector of higher education. As it is aimed at cultivating experts of engineering and technological innovation, engineering education is increasingly showing that it is of vital importance to the nation's social, technological, and economic development. At present, China is in the process of becoming an innovative country which strengthens itself through education, and the reform and development of engineering education is facing new opportunities and challenges.

Over the past 40 years, China's engineering education has developed by leaps and bounds in accordance with the country's continuous industrialization since its Reform and Opening Up. It has gone through a period of restoration and adjustment, a period of refinement and development, a period of scale expansion, and a period of quality improvement. Today, China has successfully moved from being just a big country for engineering education to being a powerful country in the field [1].

Tsinghua University has a long history with engineering education. At the beginning of the 20th century, 1,290 students from Tsinghua University went to study in the United States, 404 of which were studying engineering-related majors. In 1932, Tsinghua University formally established the College of Engineering consisting of three departments: civil engineering, mechanical engineering and electrical engineering. In the 1950s, Tsinghua University became a multidisciplinary industrial university and created the practical teaching model of "graduation design with real swords and guns", greatly advancing the development of China's industrialization. Since China's Reform and Opening Up, Tsinghua University has gradually undergone a transformation from being a multidisciplinary industrial university to a comprehensive research university [2].

As an important comprehensive university in China, Tsinghua University has been reforming its higher engineering education in recent years and has put forward the postgraduate cultivation concepts of "from academic to even more academic" and "from professional to even more professional". The research object of this paper is professional talents, namely engineering talents. Facing the urgent demand for educated experts in China's industry and the unprecedented development of international engineering education, how China's own educational systems can live up to the "from professional to even more professional" cultivation principle is a question that all engineering schools and departments ought to be asking.

This paper is divided into five parts: The first part is an introduction which outlines the importance of China's engineering education and the opportunities and challenges it faces. The second part deeply analyzes the main problems with China's engineering education and its current status. The third part proposes an innovative, organized engineering education framework as a solution. The fourth part introduces the main measures for an organized system of engineering education in detail. Finally, this paper analyzes and summarizes the effectiveness of the implementation of organizational engineering education concept.

II. CURRENT SITUATION AND EXISTING PROBLEMS IN CHINA'S ENGINEERING EDUCATION SYSTEM

A. Current Situation of the Development of Engineering Education in China

As its largest scale, engineering education occupies a vital position in China's higher education system. After the founding of New China, and particularly since the Reform and Opening Up, China's engineering education system has made great progress in sync with the country's industrialization.

Therefore, in absolute terms of scale, China is currently the largest in the world when it comes to engineering education. However, with the increasing emphasis on securing scientific research talents by comprehensive universities and research universities, and with the increasing number of graduate students engaging in scientific research, the concept of "focusing on science and neglecting engineering" is growing increasingly common throughout China's educational institutions. Naturally, this severely hampers the quality of Chinese engineering education. In addition, the engineering educational system is facing many simultaneous challenges, such as: coming up with engineering solutions and maintaining technological innovation, responding to climate change, managing interdisciplinary integration, satisfying human developmental needs, developing sustainably, etc. [3]. As such, raising the quality of the educational system and coping with the challenges within it are pressing issues which require urgent resolution. However, the problems faced by the Chinese engineering education system are systemic and complex, including the common problems faced by the global engineering education and the problems in the development process of China's engineering education itself, originating both internally and externally [4]. To carry out a systematic reform of engineering education, an effective strategy must be developed so that the educational system, the industry, the government, and any other relevant parties can all interact with each other and participate meaningfully, contributing to the entire process of educating new engineering talents.

B. Problems in China's Engineering Education

After years of unrelenting effort, great achievements have been made in the reform of China's engineering education, and a large number of engineering and technical talents have been caltivated, which strongly supports the rapid development of China's economy, and a large number of world-renowned achievements in the construction of major national engineering projects have emerged. However, with the rapid development of global higher engineering education, there are still many important issues that must be resolved. The crux of the problem is the weakening of engineering practice ability and engineering innovation ability, the imperfection of talent cultivation mechanism with multi-party participation and the deficiency of talent cultivation mode of interdisciplinary integration [5]. These problems will affect China's future industrial revitalization and scientific and technological progress. At the same time, China will also be faced with the dilemma of insufficient innovation in the field of engineering. The problems faced by China's engineering education have specifically manifested through:

1) A single talent cultivation model

With China's continuing industrialization, emerging companies of every sort have been brought to life in China. The sphere of engineering covers a wide range of fields, and the team system comprising engineers, technicians, and engineering scientists is very complicated and inevitably requires a variety of highly-trained experts produced through engineering education. However, there is currently only one engineering talent cultivation model, and since there is obviously a trend towards the combined cultivation of engineering talents and academic talents under one curriculum. The engineering education system generally does not delve into real-world industry characteristics.

2) A curriculum which lacks practical engineering content

For a long time, the postgraduate curriculum has generally been divided into basic courses, professional basic courses, and professional courses. The courses pay attention to theoretical and professional teaching, but often lack practical content. In addition, since the vast majority of teachers have not worked in engineering companies and lack industry experience themselves, the courses are often unintegrated with industry characteristics and the realities of industry practice. Therefore, curriculum does not reflect the characteristics of cross-integration with the engineering disciplines.

3) Insufficient engineering literacy cultivation

Due to the mixed cultivation of engineering experts and scientific research talents, engineering literacy cultivation for engineering postgraduate students is obviously insufficient.

Lack of practical abilities cultivation: The fundamental curriculum for graduate students mostly teaches theoretical knowledge and professional knowledge, with very few courses including practical content. This clearly makes it difficult for students to get a feel for a real industrial environment while on campus. There are fewer and fewer opportunities for students to carry out engineering practice in the campus. Many graduate courses consist only of teachers' presentations and students' observations, so it is only natural that students' practical abilities would weaken.

Low effect of corporate practice: Although enterprise practice is a compulsory part of gaining a master's degree in engineering, business practice is marred by fragmentation and an element of randomness, greatly reducing its practical effect. The main reasons for this phenomenon are the unclear orientation of the students' cultivation goals as set out by the school tutors, and the insufficient understanding of the importance of corporate practice by the departments, school tutors, and students. Some practical links are in vain and go through the scene, while in other cases there is little or no relevance between students' dissertation topics and the practicalities of the industry.

4) Teachers' lack of industrial experience

Most teachers in colleges and universities are engaged in scientific research and have never worked in real-world enterprises, meaning that they lack practical experience. On the other hand, experienced engineers in the corporate world are restricted in many aspects, making it difficult for them to enter the classrooms of colleges and universities. This leads to the possible of the cultivation goals of engineering talents in colleges and universities be out of line with the needs of the state and enterprises.

5) Insufficient industry-university-government cooperation

In China, an effective mechanism for the collaboration of universities-governments-enterprises in cultivation engineering talents has not yet been established. At this stage, the tripartite forces are scattered. Most colleges and universities primarily focus on cultivating academically-oriented postgraduates; Enterprises only position themselves as employers, not as cultivation units; and the government does not play its role as a guidance-providing policy-maker. Therefore, enterprises do not attach importance to their participation in the process of cultivating talent, meaning that the rich resources of the enterprise's practical education system go to waste.

To solve these problems with China's engineering education system, and in order to cultivate outstanding engineers that meet the needs of the country's development, it is necessary to develop an innovative model for engineering education talent cultivation, reforming the system and establishing a sound cultivation method to comprehensively improve the quality of engineering education. Therefore, we propose new concepts and methods for organized engineering education in the hope of improving its effectiveness.

III. Innovating the Concepts and Methods of Organized Engineering Education

A. *Innovating the Concept of Organized Engineering Education*

What is an "organization"? Broadly speaking, it is a system in which many elements are interconnected in a certain way. In a narrower sense, an organization refers to a collective or group in which people cooperate with each other for the purpose of achieving a certain goal. So why should we put forward the concept of "organized" engineering education in engineering pedagogy?

As we all know, engineering education involves cultivation within three parties - universities, enterprises and the government - in what is clearly a huge and complex system. However, an embarrassing situation in which theory is emphasized and practical work is neglected has arisen in the engineering curriculum of Chinese universities, especially in comprehensive and research universities, and as such, the results of engineering practice are not satisfactory. In order for engineering education to truly play its part in the production of new talents and be of fundamentally better quality, we have put forward the concept of organized engineering education. This idea for organized engineering education would mean that engineering education would take the project system as its carrier, and through the establishment of a project team, it would implement a series of ordered activities such as organized management, organized teaching, and organized practice to enhance the entire process of engineering education. On top of this, practical engineering elements would be integrated throughout the system. The educational concept of organized engineering is shown in Figure 1.

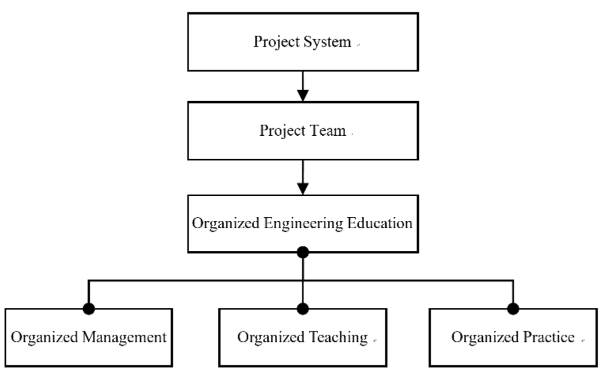

Fig. 1. Organized Engineering Education Concept

The implementation of such a concept would be of great significance to the development of large-scale engineering education and the cultivation of specific engineering professionals oriented to meeting national needs.

B. *Innovating Organized Engineering Education Methods*

We have come up with innovative new methods for organized engineering education in line with what an ideal system would look like. From the administrative management level, we have opened up multi-level parties such as the graduate school, department, and practical education base (PEB), and then established a mechanism for multi-level management linkage. We have then proposed a joint framework for cultivating new engineering talents which involves universities, governments, and enterprises. With the goal of producing new talents, we set up a course teaching group to carry out organized teaching. We have effectively integrated both practical teaching and corporate elements into the curriculum, and formulated cultivation programs that meet the characteristics needed for cultivating engineering professionals. On top of this, we have established the PEB. Every year, we arrange for 30-50 students to enter a PEB in a unit with their class in order to undergo organized engineering practice.

IV. Specific Measures of Innovative Organized Engineering Education

A. *Organized Curriculum Teaching*

Curriculum teaching forms the foundation for the education of talents in colleges and universities. The quality of curriculum teaching correlates with the quality of postgraduate cultivation and the postgraduate aptitude for innovation. Since 2019, we have established a three-level organizational structure centered on the Departmental Teaching Committee. The teaching affairs management of the Department of Automation is its service organization and the course teaching group is its executive body. This structure is giving the Department Teaching Committee and the course teaching group actual teaching powers. As a result, we have established a multi-subject benign interaction and effective collaborative development mechanism of graduate education, and established a management system of graduate education with internal vitality.

1) Establishing course teaching groups for the purpose of cultivating engineering talents

Under the promotion of the Department Teaching Committee and project team, the curriculum teaching team is established from two dimensions. The first dimension is based on the course content and application direction. Two categories of eight course teaching groups are established. One major category is that of the basic lesson group, which includes the control course group, the computer course group, the electronic course group, and the mathematics course group. The other major category is of the professional course group, which comprises the artificial intelligence course group, the optimization and decision-making course group, the robotics course group, and the information and big data course group. The second dimension is to formulate engineering course teaching group with the goal of cultivating engineering talents. These groups includes the control engineering courses group, the big data courses group, the engineering technology course group, and the engineering management group. The course group construction is shown in Figure 2.

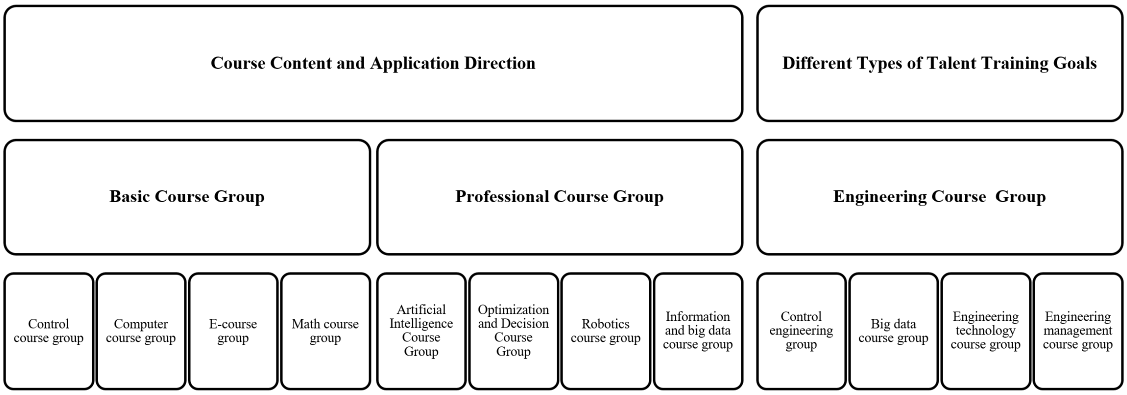

Fig. 2. Course teaching group construction

The establishment of these groups is of great significance for optimizing the curriculum, perfecting the system, and cultivating engineering talents with specific goals. This method is tailor-made, as only by teaching a course specifically suitable for a certain type of engineer can we cultivate diverse engineering talents.

2) Integrating theory with practical elements

How can one rationally balance theoretical courses and practical courses in order to obtain the optimal effect? In order to bridge the gap between theory and practice, the Department Teaching Committee noted three points: The first is that 3-6 credits of practical courses should be taken for a Master of Engineering (M.E.). This means that the completion of practice in the industry is one of the basic requirements for graduation. The second is that the goal of teaching must shift from being solely to impart knowledge to focusing on cultivating ability. The third point is to integrate practical courses with theoretical ones and oppose their separation and isolation. Through these stipulations, students will learn both theory and practice at the same time. They will apply the theories directly to the practical aspects of the curriculum, greatly improving the efficacy of the theoretical courses and laying a solid foundation for the cultivation of engineering talents.

On a typical university campus, practical lesson hours should be incorporated into the curriculum. For example, the course "Software and Hardware Designs for Embedded Systems" takes a total of 48 class hours, of which 24 hours are on theoretical knowledge and 24 hours are on practical knowledge. The course "Probability Graphic Model Theory and Methods" is also 48 hours in length, 32 of which are theoretical, and 16 of which are practical. "Terahertz Detection and Imaging Technology" totals 48 class hours, including 42 hours of theory and 6 hours dedicated to practical knowledge. Off-campus, we have established different types of PEB to carry out enterprise practice in an organized manner.

3) Cooperate with companies to offer practical courses

Engineers in contemporary society need to understand the design process for a product, along with the social, commercial, technological and humanistic environment in which the product is located, more than ever before [6]. Therefore, it is necessary to integrate enterprise elements into M.E. courses. The project team encourages the delivery of corporate courses and invite enterprise tutors to become teachers of practical courses so that they can fully participate in the process of cultivating new engineering professionals. This is an important aspect of our proposal for the improvement of the engineering education system. The specific approach is as follows: During the formulation of the course plan, the project team will invite an enterprise to participate. By doing so, the teaching content will reflect, to a certain extent, the latest needs of society and the industry and thus it will be clear what kind of talent is needed. In the courses, real case studies related to project development and product design will be introduced so that M.E. can learn about the latest developments in industry and technology [7].

For the big-data engineering cultivation project, the project team has selected a number of outstanding enterprises which can contribute to the process of talent cultivation. The practical guidance courses offered by enterprise tutors are shown in Table I. Cooperating with enterprises to offer practical courses is of great significance for the enhancement of the enterprise's awareness of educating new professionals, fully tapping into the enterprise's educational resources, and enriching the content of engineering cultivation courses.

TABLE I. COURSES OFFERED BY ENTERPRISE

Course Title
Integrated application of big data and government management
Big data and real economy integration application
Blockchain, the technological revolution of the modernization of the national governance system
"Digital Human Society" helps people's livelihood services
Practice and exploration of the construction and development of Guizhou e-government network
Practice and exploration of Guizhou provincial government website construction and development

B. Organized practical education base construction

1) Top-level design of a practical education base construction for engineer-cultivation objectives

Focusing on the country's demand for engineering talents, we have done a good job of top-level design and expanding the construction of PEB. The cultivation of big data talents is an good example for this point. In order to better promote the in-depth integration of various industries such as the internet, big data, and artificial intelligence, and to face the national cultivation needs of innovative big data professionals, we have repeatedly visited numerous local governments to conduct surveys. Combining the characteristics of the local industries' development and the government's needs, and with the support of the school's graduate department and the local government, we have built a batch of practical education bases for students of engineering.

In 2016, Guizhou Province proposed a construction plan for the development of the big data industry, and changed from being merely a follower of big data to a leader of the field. Tsinghua University seized the opportunity for the construction of the Guizhou Big Data Pilot Zone and explored and established a new model of university-government-enterprise cooperation in big data talents cultivation. In 2017, the "Guizhou Big Data Full-time Master of Engineering Program" was established. Relying on the project system, we established the "Guizhou Big Date Graduate Practical Education Base" in Guiyang City, Guizhou Province. At the end of three years of construction, 110 big data students were enrolled at the base. Each class of students was to undergo industry practice for one and a half years in a enterprise in the direction of big data in Guiyang City, Guizhou Province. Following its construction, the PEB has achieved remarkable results in the promotion of collaborative innovation in production, education and research, and has given full play to the role of radiation demonstration of technological innovation carriers.

As the source and site of practice for China's digital strategy, Fuzhou is accelerating the creation of "the first city of digital applications in the country." In recent years, industries such as cloud computing, big data, artificial intelligence, the Internet of things, and block chain have grown from nothing, going from insignificant to giant, and are now at the forefront of the country. In 2016, Fuzhou was selected to be in the first batch of pilot cities for healthcare big data centers, and the construction of the first set of pilot projects began. The Fuzhou Municipal Government and Tsinghua University have cooperated closely for many years. In November 2017, the Fuzhou Institute of Data Technology was established to focus on the innovation and application of big data technology. Following this, we are preparing to build a Fujian Big Data Graduate Practical Education Base, and in this way we hope to be fully prepared for the cultivation of medical big data engineering talents.

In the future, faced with big data and the demand for experts in other areas, we will continue to explore practical bases with good application scenarios across the country.

2) System construction of a practical education base

How we can better improve students' practical aptitude and ability to innovate is a key issue that needs to be considered in engineering education. With the aim of increasing the practical education base's efficacy, the project team vigorously strengthened the system's construction.

Firstly, we established a tutor selection system. The project team strictly controlled the quality of enterprise tutors and innovatively established a series of systems for enterprise tutors selection, pre-employment, cultivation, assessment and incentives so as to give full play to the role which enterprise tutors can play in guiding students to carry out engineering practice. It is particularly worth mentioning that the project team established a novel dual tutor matching system of "pre-research results". In the past, enterprise tutors often neglected their role as a main player in the education process, making them unable to fully participate in cultivating the next generation of engineering experts. In order to enable enterprise tutors to truly take part, the project team selected enterprise tutors through the "pre-transformation of scientific research results" method to achieve the best match between enterprise tutors and university tutors. The dual-mentor matching system of "scientific research results in advance" is shown in Figure 3. In the first step, university tutors select enterprise tutors who are an appropriate match based on the direction of their own research, forming a tutor group which is in accordance with their future work. In the second step, the M.E. who participated in the enterprise practice selects the tutor group that is consistent with the direction of their enterprise practice. This increases the chance of an ideal match based on the directions of the university tutor-student-enterprise tutor's tripartite research and practice. In the last step, in order to even further improve the compatibility of the three parties, the project team also implemented the "enterprise tutor pre-appointment system", which gives the enterprise tutor a three-month pre-appointment period. At the end of the three-month pre-employment period, if the three parties have reached an agreement on the enterprise practice link, the enterprise tutor can be formally hired. Otherwise, enterprise tutors will not be eligible for tutorship.

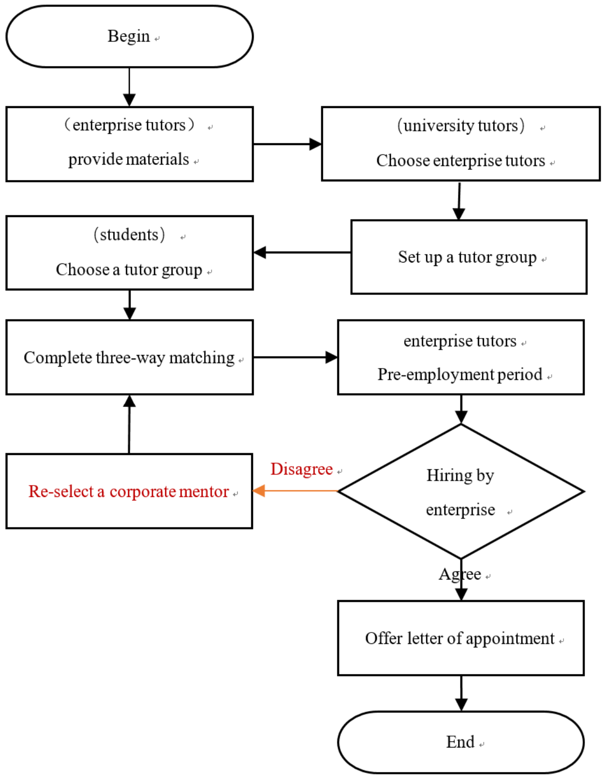

Fig. 3. Double-tutor matching system

Meanwhile, the project team strictly controlled the quality of university tutors, establishing a system for the appointment, assessment and elimination of tutors and maximizing tutors' ability to assist students with carrying out their research. When reviewing the qualifications of the university tutors, the project team focused on whether they had cooperative experience with big data enterprises in Guiyang City, Guizhou Province, as this would better prepare students for entering the workplace and carrying out corporate practice. Every year, the project team evaluates university tutors with the formulated tutor evaluation method. When students' dissertations do not meet the criteria for an M.E., the project team will suspend the university tutors' enrollment qualifications for one year.

Secondly, we strictly control the quality of students. The project team implements "full-process, high-quality" management for students who carry out industry practice in the base. The project team has established a cultivating guidance group, which is made up of senior university tutors and experienced enterprise tutors. The cultivating guidance group regularly provides feedback on the quality of students' cultivation and puts forward improvement plans: Setting up special projects for bilateral scientific and technological cooperation, promoting in-depth cooperation and the transformation of scientific and technological achievements, and improving the quality of research. The project team has implemented an elimination system based on opening reports and thesis pre-defenses to strictly control the quality of dissertations. For students who cannot integrate their topics with the practicalities of the industry, the cultivation guidance group will implement a "one-vote veto". Students who fail the pre-defense will have their graduations postponed. The project team carried out evaluations of practical results and attached great importance to the application of, and innovation in, students' practical findings.

Finally, we established an enterprise selection system. The choice of enterprise is the most critical part in the process of students undergoing the practical component of their course. The kind of enterprise that can be used as a place for students to practice is one of the most pressing issues for the project team. Every year, the project team publishes the enterprise selection rules in advance, and then the expert team hired by the project team will evaluate the enterprises that apply to take part in the cultivation program. Finally, the university tutors make their decision as to which enterprises match the direction of their research. Only enterprises that pass this screening can enter the talent cultivation program. These measures are in place to adequately prepare for enterprise practice and maximize its effectiveness.

3) Cultural construction of a practical education base

Being kept from the campus environment can become an issue over the course of long-term practical work at enterprise locations. Staying away from campus can foster feelings of isolation and may damage the mental health of students. The project team considered this issue in advance, and decided to solve the problem by carrying out cultural construction within the PEB. Campus cultural construction mainly includes material cultural construction and spiritual cultural construction. Good campus cultural construction can guide students' thoughts, edify their emotions, temper their will and shape their personality [8].

On the material cultural construction, the big data project team guided the base to build a humanistic university campus which integrated both educational and practical functions, including building a cultural wall with university campus elements, talking room, activity room, sports venues; equipping with life tutors, class directors, moral education teachers. and organizing rich cultural and sports activities.

On the spiritual cultural construction, students carry out practice in the enterprise on weekdays; Meanwhile, students carry out academic exchanges, theme class meetings, and cultural and sports activities on weekends. Various forms of lively collective activities create a positive atmosphere for the class. For example, 2018 class of "Guizhou Big Data Full-time Master of Engineering Program" was rated as outstanding by the school many times, which thanking to the efficacy of establishing this culture.

Organized cultural development in the base can strengthen communication between students, enhance the cohesion of the class, and to a certain extent, effectively avoid potential social and psychological problems.

4) Establishing an engineering research center in a planned way

In order to meet the developing needs of the economy, the field of technology, and engineering education, we have gradually formed a group of university-enterprise joint research centers that have close industry links. We have cooperated with Apple, Meituan, Yidu Cloud, and other enterprises to establish multiple research centers in the cross-cutting fields of intelligent manufacturing, intelligent unmanned systems, digital life, biological manufacturing, and medical care. On the one hand, the establishment of a joint university-enterprise research center promotes the development of scientific and technological research in the field of engineering in a way that is oriented to national needs; on the other hand, it improves the cultivation outcomes of engineering students.

C. Organized Engineering Practice

In order to improve the outcome of engineering practice, the project team oversaw the management process throughout and evaluated the effects of the engineering practice.

1) Strengthening the management of engineering practice

Engineering practice is carried out in a remote enterprise. The practice period lasts for one and a half years. During this time, students may encounter many problems in terms of their daily life, mental health, academics, and practice. These issues are not isolated, but interrelated. In order to solve the various problems encountered by the students in a timely and effective manner, the project team has established a special management team to oversee the engineering practice. This team includes class teachers, teaching affairs management teachers, life tutors, psychological tutors, and enterprise practice management teachers. The establishment of this project management team not only effectively solves the problems and difficulties encountered by students during their practice, but also acts as a basic guarantee for the organized development of engineering practice.

2) Strengthening the evaluation of the engineering practice process

In order to verify the outcomes of engineering practice, the project team established a series of evaluation systems, such as corporate tutor evaluation, dissertation evaluation, engineering practice evaluation. The project team will withdraw the qualifications of enterprise tutors who have failed to correctly guide practicing students during the pre-employment period. For dissertations which do not meet the needs of the enterprise, the project team implements a "one-vote veto". On the eve of graduation, the project team will organize a selection of outstanding work done during engineering practice.

For example, in 2020, the project team carried out the evaluation of 30 practical pieces of work from the 2018 "Guizhou Big Data Full-time Master of Engineering Program", 16 of which achieved relatively ideal practical results. These included: "Research into atrial fibrillation detection algorithms based on wearable devices", "An intelligent configuration, optimization and coordinated decision-making method for multi-functional units in complex working conditions", "The detection of abnormal working conditions in a cloud manufacturing environment", "Graph-based convolution", "Neural network-based road network traffic speed prediction", and other engineering practice projects. It is particularly worth mentioning that the results of "Remote sensing precipitation retrieval project based on machine learning" have effectively improved the reliability of precipitation forecasts and helped companies to develop breakthrough technologies and make major innovations. The chairman of the Academic Committee of the Department of Automation commented that "these research results are rich in content, high in level, and strong in logic. They can effectively solve the actual engineering problems in certain fields of the industry, and can be directly integrated with real-world technical needs."

The establishment of a mechanism for whole-process management and a series of evaluation methods is an important measure for the project team to carry out engineering practice in an organized manner. This plays a vital role in comprehensively improving the quality of engineering education.

V. Summary

A. *Effectiveness analysis*

In the world, the establishment of interaction mechanism between universities and enterprises is an important issue to be solved in higher engineering education. At the centennial celebration of Peking University, when reviewing the success of Stanford University, G. Caspar, the president of Stanford University, pointed out that the establishment of close cooperation between the university and industry is one of the elements of the success of the university. He stressed that close cooperation between universities and enterprises has become the trend and requirement of globalization. As a miracle of the world economy, "Silicon Valley" is the result of close cooperation between Stanford University and the business community [9].

The core of the concept of organized engineering education is to establish an effective mechanism of interaction between enterprises and universities. After years of exploration, the implementation of organized engineering education concept has achieved initial results. Guizhou Big Data Graduate Practice Education Base, since 2017, has organized a series of interactions with the enterprise community, and now has formed a "Guiyang Model": with the joint efforts of the Department of Automation in Tsinghua University, Guizhou Big Data Bureau, Guiyang National High Tech Zone Management Committee and Guiyang big data enterprises, the PEB has gradually become an important cultivation base for the cultivation of big data innovative talents and an important carrier to promote the collaborative innovation of government-university-enterprise. Therefore, PEB has formed a professional, practical and professional "Guiyang Model". It is worth mentioning that this mode has been extended to Fuzhou City, Fujian Province, where gathering medical big data resources. While imitating the "Guiyang Model", we further explore the more effective mechanism of "Fuzhou Model" for medical big data talent cultivation.

Under the concept of organized engineering education, the government department is no longer just a "matchmaker", but a "practitioner"; the enterprise is no longer a "bystander", but a "participant" as the main body of talent cultivation; colleges and universities are no longer a "lone walker", but a "collaborator". Undoubtedly, all of these pave the way for the integration of cultural values of all parties and the reduction of the conflict of goals and behaviors caused by the differences in cultural values. In order to further improve the effectiveness of organized engineering education, we look forward to more effective work from the following aspects: The government should increase support for the implementation of organized engineering education from the aspects of policy, funding and publicity; Enterprises should change their development ideas, use "external brain" and attach importance to the cultural value integration in the process of organized engineering education; Colleges and universities should strengthen the publicity of engineering personnel cultivation and scientific research results, and further strengthen cooperation with enterprises.

B. *Conclusions*

Over the past 40 years of the Reform and Opening Up, China's engineering education has made great strides. This is in line with the tremendous economic and social changes which the country has undergone, along with the historic leap that general higher education has made, all of which has significantly contributed to China's industrialization. However, due to the imperfect engineering education system, China's engineering education has been imbalanced between theory and practice. The current system of engineering education in China generally lacks practicality and innovation, restricting the production of innovative engineering talents. Based upon many years of practice, the contents of this paper show our remarkable results in the cultivation of engineering students in Tsinghua University. There are many key factors that have had a positive effect on the establishment of an organized system for engineering education. Firstly, the most important factor is that the talent cultivation goal of higher engineering education should meet the needs of the country and the sustainable development of the society [10]. Higher engineering education is more than course, and more than industry cultivation [11]. We must closely integrate the curriculum and industry cultivation with the improvement of engineering innovation ability and the cultivation of engineering literacy through an organized form. We expect to achieve the "Trinity" high-level talent cultivation goal of "value shaping, ability cultivation and knowledge imparting". Secondly, industry need, no doubt, is a fundamental factor in the implementation of an educational concept for organized engineering education. In addition, the project team has always felt an unwavering determination to face any difficulties they might encounter with this project head-on. This attitude was critical to their success. Finally, the administrative support received for the engineering cultivation project helped the team overcome resistance and fueled their motivation. The project received general support from the university's provost, the dean of the graduate school, and the department heads of the graduate school. Without this strong administrative support, progress may well have ground to a halt.

In recent years, Tsinghua University has been exploring effective ways to cultivate high-quality talents in engineering education. We are leading the charge and have already made some reforms in engineering education. We hope that through this concept of "organized engineering education", we can produce truly outstanding, innovative engineering talents who come from all walks of life for the good of the country.

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