A New Training Mode and Practice for Master of Engineering in a Chinese University

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***Abstract*—This Innovate Practice Full Paper presents the past process of the full-time Master of Engineering (M. Eng.) education in China, which is designed to meet the requirements of the China's innovation of science and technologies. Under the current trend of the economic globalization and the internationalization of higher education, China's higher engineering education (HEE) must carry out certain reforms to adapt to the new changes and development of the country. In China's HEE, M. Eng. program can be divided into two categories: in-service M. Eng. program and full-time M. Eng. program. The graduate students of the former program come from the employees of enterprises and study in their spare time, while the graduate students of the latter program mainly come from the fresh graduates of universities and they spend their full time for study. Normally they both spend 2 to 3 years to finish their master programs. This paper mainly discusses the current situation of full-time M. Eng. education, and analyzes the corresponding difficulties from the following four aspects: insufficient clarity in the training goal, incompleted Dual Tutor System, unsatisfactory enterprise practice, and insufficient interaction between university and enterprise. Therefore, full-time M. Eng. education still faces some immature situation and has higher demand for the innovation. This paper takes the big data full-time Master of Engineering (BDFM) training as a case, and introduces a new training and practice mode in a Chinese university, including project management, establishment of Practice Education Base (PEB), course construction, design of mechanism of PEB, as well as the establishment of Dual Tutor Matching Mechanism (DTMM). Considering the internationalization of HEE under China's national conditions, we show how to speed up the educational reform of M. Eng., how to implement educational innovation, how to promote the engineering education to better adapt to the needs of economic and social development, and how to play the exemplary role of this new training mode. We hope our study could contribute to the sustainable development of HEE over the world.**

Keywords — Master of Engineering, higher engineering education, dual tour，practice base

I. INTRODUCTION

In the past decades, two master programs have been established for different purpose in China, i.e., Master of Science (M. Sc.) program and Master of Engineering (M. Eng.) program. The former is to train the graduate students with the ability of academic research and the latter is to train the graduate students with the ability of engineering. The scope of M. Eng. is wide, including software development, computer technology and aerospace engineering, etc.. The scope of M. Eng. introduced in this paper is control engineering.

With the rapid economic development, China is in urgent need of training a number of high-level engineering talents who are suitable for the industrial development. The development of the China's M. Eng. education can be divided into two stages. The first stage is training the in-service M. Eng. that started in 1997 when China began to promote its national economy and to enrich the types of graduate students. Specifically, China selects a group of employees from enterprises who are willing to improve their engineering technology capabilities, and carries out the graduate degree education. In 1997, there were only 1525 in-service M. Eng. enrolled in China, while the number of enrollment increased rapidly and reached 57146 in 2007 [1]. As society gradually presents new demand for high-level, application-oriented scientific and technological innovation talents, the in-service M. Eng. should have both strong engineering practice ability and strong engineering innovation ability. Unfortunately, the traditional in-service M. Eng. training mode does not meet such requirements.

Since 2009, China's M. Eng. education has entered its second stage, namely, to increase the training types of full-time M. Eng.. At that moment, China has begun to recruit the fresh graduates to full-time M. Eng. [2], aiming to cultivate a group of compound and high-level technical innovation talents. Figure 1 shows that the number of full-time M. Eng. in one engineering department of Tsinghua University has increased from 26 (3% of the total number of graduate students) to 223 (21% of the total number of graduate students) within 10 years, reflecting the increasing trend of the full-time M. Eng. education, over the recent years.

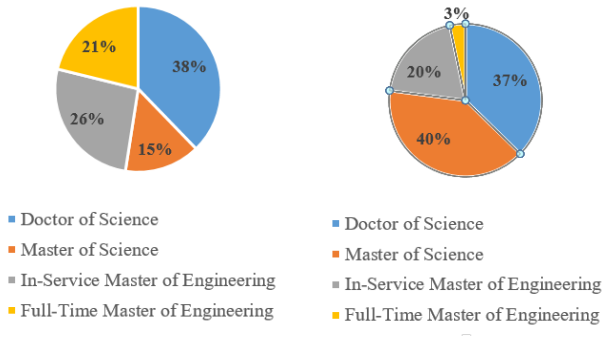

Fig1. Distribution of graduate students in 2010 (left) and 2019 (right) in one department of engineering of Tsinghua University

The object of in-service M. Eng. education is the employees of the enterprise who complete their studies in their spare time, while the object of full-time M. Eng. education is the newly graduated undergraduates who have not yet been employed. The research object of this paper is the full-time M. Eng..

From the analysis of employer' feedback, the full-time M. Eng. trained by Chinese universities have a strong ability to grasp the theoretical knowledge. However, most of them

find it difficult to apply the learned knowledge directly into practice. They often need to spend a long time to continue learning before they become skillful at the work [3]. Therefore, the way to improve the engineering practice ability of students and to play a positive role at enterprises becomes the most critical issue in the innovation of full-time M. Eng. education. Since the enrollment of full-time M. Eng. in 2009, China's HEE has been seeking for educational reform and innovation, striving to open a new and effective way for full-time M. Eng. training.

In this paper, we mainly focus on promoting social functions of full-time M. Eng. education, and making due contributions to the improvement of enterprise innovation ability and the development of national economy.

In recent decades, in order to enhance the quality of engineering education, some significant efforts have been made for the engineering education in the international engineering education community. For example, South Korea tries to better adapt to the rapid development of society by the following measures: expanding budgets, constructing education and research infrastructure, securing excellent faculty and demand-oriented (or based) engineering education. It is worth mentioning that Hankyong National University actually designed engineering clinical courses, so as to solve practical engineering problems [4]. In Universiti Teknologi Mara Malaysia, undergraduates used the Problem Based Learning to complete final year industrial projects in the undergraduate program for mechanical engineering with the supervision of one university tutor and one industry tutor, helping students become better engineers [5]. However, not all universities establish mechanism to enhance the quality of engineering education by university-enterprise cooperation. The research work of this paper attempts to carry out relevant attempts.

The originalities of this paper are as follows: First, facing the new situation of China's economy, we propose a new training mode of master of engineering based on the project system; Second, based on the integration between industry and education, we build a practice platform for the sustainable development of the new training mode of master of engineering; Third, to meet the major needs of industries, an innovative platform is built for research and education. Moreover, the conversion of achievements of the industrial-academic-research cooperation was carried out, so as to form a demonstration effect for the sustainable development of high-level engineering talents' training.

This paper is organized as follows: Section II describes the difficulties faced by full-time M. Eng. education in China. In Section III, we take a full-time M. Eng. project as an example to describe a series of reform measures in detail. In Section IV, we first carry out a preliminary effectiveness evaluation of the measures through a personal interview, and then introduce the future work of the project in detail. Conclusions are made in Section V.

II. DIFFICULTIES FACED BY CHINA'S FULL-TIME MASTER OF ENGINEERING EDUCATION

During the past 10 years' development of full-time M. Eng. education, China has accumulated a lot of experience in talent training, including the establishment of Dual Tutor System and the development of enterprise practice, etc.. However, there are still many difficulties. For example, China's full-time M. Eng. education system has not yet set up a joint training mechanism from university-government-enterprise (U-G-E). In the full-time M. Eng. training, the role of the government is not clear and the power exerted by enterprises is weak. Hence, the universities are lonely in this process. The above problems will act as constraints when full-time M. Eng. tries to improve the engineering practice ability and engineering innovation ability.

A. Insufficient Clarity in the Training Goals

The education policy formulated by the government clearly stipulates the training goals of full-time M. Eng., i.e., training a group of high-level engineering and technical talents with innovative and practical capabilities for the country and society, and meeting the urgent talents needs of industrial sustainability. In fact, compared with M. Sc., M. Eng. is a new thing. Therefore, in the past 10 years, universities, enterprises and the society have not fully understood the training goals of the full-time M. Eng..

First of all, the universities do not well understand the training goals. For a long time, the focus of talent training in universities is the academic graduates, e.g. M. Sc.. Meanwhile, the universities have accumulated rich experience in M. Sc. training. In a sense, since the universities are not well prepared for full-time M. Eng. training, so there are not enough teachers with engineering practice experience. In addition, the tutors in the universities do not understand the true meaning of full-time M. Eng. education, and the boundary between the education of M. Sc. and M. Eng. is blurred [6]. The tutors in the universities, especially research-oriented or comprehensive universities, can easily confuse the training goals between M. Eng. and M. Sc.. For example, some tutors pay more attention to the scientific research ability of M. Eng., during the cultivation process, but do not pay attention to the practical ability. Therefore, for M. Eng. training, the tutor only emphasizes on the publication of academic papers, rather than the solution of complex engineering problems.

Secondly, the enterprises do not well understand the training goals. One of the important goals of the full-time M. Eng. education is to train high-level technical innovation talents for the business community, so that the enterprises can improve their core competitiveness and achieve their long-term development. As the most direct beneficiary, enterprises were expected to pay the greatest attention to the implementation of education policies. However, the reality is that enterprises do not care much about the quantity and quality of full-time M. Eng.. In fact, the effort of them is weak in the process of training. The main reason is that most enterprises are pursuing the maximization of the profits in a short term, while they usually do not care how to achieve long-term development by enhancing their core competitiveness, i.e., the talents and the technology. Unfortunately, this is exactly the current status of many Chinese enterprises.

Thirdly, full-time M. Eng. training is lack of social recognition, which is also caused by the society's unclear understanding of the training goal of full-time M. Eng.. Insufficient social recognition is manifested in many aspects. For instance, some parents disagreed with their children the studying for a full-time M. Eng.; Some students prefer hands-on practice of scientific research, but they were reluctant to choose M. Sc. for their future study; Some enterprises prefer to choose M. Sc. as their employees. People cannot accurately distinguish between M. Sc. and M.

Eng.. They blindly believe that the level of M. Sc. is higher than that of M. Eng. [7]. These social prejudice, in some sense, will affect the development of full-time M. Eng. education.

B. *Incompleted Dual Tutor System*

The "Dual Tutor System" (DTS), originated in the early 1990s [8], is a special M. Eng. training system. It refers to equipping full-time M. Eng. with two instructors on and off the campus. The university tutor focuses on the academic guidance of students' research, while the enterprise tutor focuses on the engineering practice. The DTS was established in order to effectively compensate for the lack of engineering practice experience of university tutor, to promote the coordination between the university tutors and enterprise tutors, and to jointly cultivate a high-quality M. Eng.. However, because China has not yet set up a comprehensive joint U-G-E talent training mechanism, the DTS could not show either its advantages nor its implementation effect. On the one hand, the university tutors have reputation in the academic community, and spend more time leading and arranging students' learning and scientific research. Therefore, they normally do not prefer their students to take practice job in enterprise. In fact, the connection between the students and university tutors would even be weakened if they practice in the enterprise. On the other hand, although enterprise tutors have rich engineering experience, they are too busy to train the students. In fact, enterprise tutors are not willing to spend time on guiding students, not say the willingness to actively cultivate students [9].

C. *Unsatisfactory Enterprise Practice*

Enterprise practice is an indispensable and important link in the training of full-time M. Eng., where the students are required to perform engineering training for no less than 6 months according to high standards of full-time M. Eng.'s degree thesis. However, the actual implementation process of enterprise practice is not satisfactory. Firstly, the time of enterprise practice is not guaranteed. In a random interview, we found that individual students do not plan their time well for enterprise practice. For example, student A was so busy with the research project from his university tutor that he did not even go to the enterprise for practice till the end of the last semester. Secondly, contents of the research and enterprise practice are not consistent with each other. According to a survey from 50 full-time M. Eng. graduates in a certain year, though the research topic of M. Eng.'s degree thesis should come from the actual needs of the enterprise, it is found that 80% of the graduates' thesis are almost irrelevant to the enterprise practice, 12% of the graduates' thesis is related to the enterprise practice, while only 8% of the graduates' thesis can match the enterprise practice.

D. *Insufficient Interaction between University and Enterprise*

Seen from the past 10 years, the university-enterprise interaction in full-time M. Eng. training was insufficient. On the one hand, the enterprises did not actively participate in the design and implementation of the full-time M. Eng. training, such that the effectiveness of enterprise practice is greatly diminished. On the other hand, most enterprises and universities did not establish effective cooperation. The reasons are three folds: Firstly, the enterprises did not have strong motivation for independent innovation, since they have less demand for innovative technology and innovative talents. Secondly, there is no effective platform for universities to communicate with enterprises; Thirdly, the government has insufficient requirements for independent innovation of enterprises, which is also the key reason for the lack of interaction between universities and enterprises.

In short, it is urgent to continue the reform and the innovation for full-time M. Eng. training. Through the cooperation among U-G-E, a more completed talent training mechanism for full-time M. Eng. could be established to involve the enterprises in talent training.

III. REFORM AND INNOVATION OF FULL-TIME MASTER OF ENGINEERING TRAINING MODEL

The talent training goals of HEE is to match the needs of rapid national economic development. In order to cultivate a batch of M. Eng. in the direction of big data, Tsinghua University has set up the big data full-time Master of Engineering (BDFM) project in 2017, which was jointly constructed by the Guizhou Province Government and Tsinghua University. This project opens up a new path for U-G-E to jointly cultivate full-time M. Eng. through cooperation. Starting in 2018, the project enrolls 30 students each year. The age of the students is around 21 years old, and most of them are fresh graduates without work experience. The project has carried out a series of reform and innovation measures, including base construction, curriculum construction, mechanism construction, etc.. The target is to further promote U-G-E cooperation as well as the transformation of university-research into product. The project aims to cultivate a large number of high-level, innovative and practical engineering and technical talents for China's big data industry development, and provides valuable experience for the sustainable development of the world HEE.

A. *Project Management*

Figure 2 shows that in the past 10 years, the number of full-time M. Eng. enrolled in an engineering department of Tsinghua University has increased significantly, especially in the last two years.

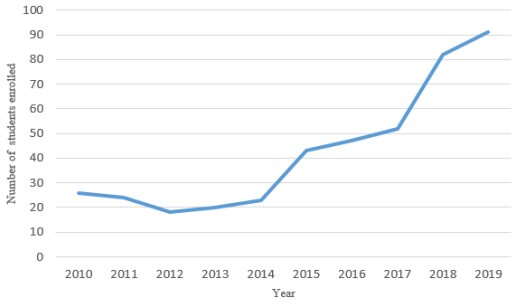

Fig.2 Trend of enrollment of full-time M. Eng. in a department of engineering of Tsinghua University (2010-2019)

How to get a qualitative breakthrough from a quantitative effort and then achieve the sustainable development of M. Eng. education. To answer this question, Tsinghua University has continuously innovated the education mode and has adopted a project based management mode (PBMM) for the BDFM training. Specifically, PBMM is an organization form that completes a one-time task with clear expected goals within limited time and resources. The one-

time task should also be done following the inherent logic of things. The BDFM project execution cycle is three years.

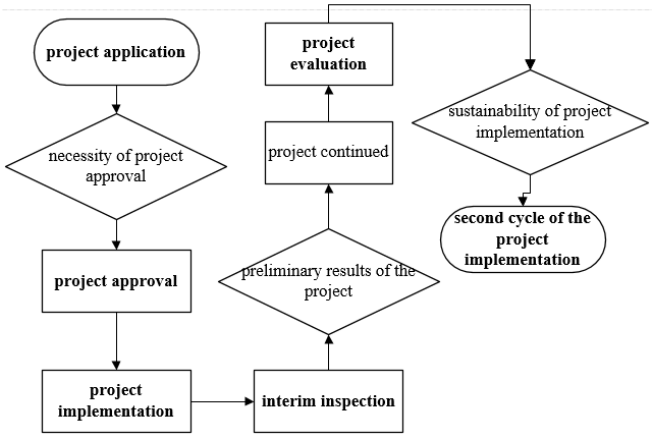

Fig.3 Project management mode

The Graduate School of Tsinghua University supervises the whole process of BDFM project, including project application, mid-term inspection, project evaluation, and tracking the effectiveness of talent cultivation. Figure 3 shows the PBMM. Specially, during the project application stage, the Graduate School fully evaluated the significance, the measures, the guarantee, the short-term objectives and the long-term objectives of the project. Only those projects that passed the assessment can be approved. During the project process, the Graduate School conducted mid-term inspection, trying to understand the difficulties and provide some guiding suggestions. At the end of the 3-year cycle, the Graduate School will evaluate the project, and only the qualified project can continue to be executed. it is seen that PBMM is based on evaluation and could better promote the continuous innovation of the training methodology. Moreover, PBMM is an active attempt for full-time M. Eng. training mode.

In order to improve the effectiveness of PBMM, a project team should be built, including project leading group, steering committee and working group. The leading group makes decisions on major issues in the process of project implementation. The steering committee provides professional suggestions, and formulates the corresponding work plan. Moreover, the working group carries out various tasks such as the arrangement of course learning, the organization of enterprise practice, the management of accommodation, and the tracking the effect of the practice, etc.. All the above tasks need to be completed in Guizhou. Figure 4 clearly shows the composition of the project team and its responsibilities. It is worth mentioning that, the project team tries to fully mobilize the role of government and enterprises, assuring them to actively participate into the entire process of talent training. In fact, the Guizhou Province Government has always acted as General Commander during the implementation of BDFM project.

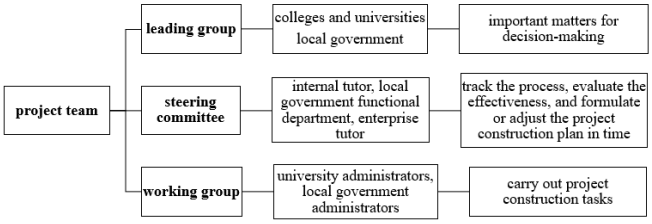

Fig.4 Project organization chart

Every year, the project team organizes seminars and symposiums that are host by the Guizhou Province Government, and invites university tutors and enterprise tutors to participate. There are many advantages: Firstly, the project team timely understood the working status and difficulties encountered by U-G-E, so as to make timely feedback and adjust the plan. Secondly, university tutors and enterprise tutors could effectively communicate during the seminars.

In short, the PBMM attempts to break the embarrassing situation of solely relying on universities to carry out the full-time M. Eng. training.

B. Establishment of Practice Education Base

In China, the development of full-time M. Eng. has been lasting for more than 10 years, but the traditionally adopted Enterprise Practice Base (EPB) has its limitations, seen as follows:

Firstly, most EPBs are separately distributed throughout the country. Students chose the enterprises subjectively and arbitrarily, which is not convenient to achieve a unified talents cultivation for a specific direction of country's development.

Secondly, since students carry out a short-time practice in EBP, it is difficult for them to solve practical problems of enterprises. Therefore, not many companies are willing to accept students for practice.

Thirdly, enterprises are greatly affected by market fluctuations, and it is difficult for EPB to be sustainably developed [10]. For example, a small enterprise affected by the market has trouble even paying its employees, and its economic efficiency is very poor. Thus, the enterprise has little energy to consider the enterprise practice that may be a burden for them.

Project team of PBMM then tried to change the traditional way of choosing EPB. Guizhou Province of China has climate advantages for the establishment of big data enterprises. Hence, It has become a leader of China's big data industry. A good question is how to make use of big data resource in Guizhou Province for BDFM training. After completing a full survey and investigation of Guizhou Province, Tsinghua University decided to adjust the plan of full-time M. Eng., and built a big data-oriented practical education base in Guizhou Province to train big data talents. Through the cooperation between the government and universities, the project team selected Guizhou Province, which has attracted many big data enterprises, as the base for students to carry out enterprise practice in a centralized way.

In 2018, Tsinghua University and Guizhou Province Government signed "a Big Data Graduate Practice Education Base Construction Agreement", which enabled the U-G-E cooperation for BDFM training. This marks the formal establishment of big data graduate practice education base (PEB). In February 2019, 30 BDFM students were allocated to PEB and started their enterprise practice. Compared with EPB, PEB has not only practical functions but also educational functions. The project team requires that university tutors should often go to PEB to carry out teaching activities, students guidance and other educational activities.

During the construction of PEB, the project team overcame various difficulties and constantly explored new methods for BDFM training. The project team designed strategy to construct PEB. Training students at PEB has the following advantages:

Firstly, the PEB is funded by the government, while the university and enterprises participate in the joint construction. For example, enterprises are jointly selected by the government and university. The selected enterprises should have certain production scale and technical strength, and can provide graduate students with compatible opportunities for large-scale or complex engineering practices.

Secondly, the physical address of PEB is uniform. Students should be centralized inside the base for accommodation, study, scientific research and enterprise practice. The project team conveniently chose a batch of excellent big data-oriented enterprises as the practice base.

Thirdly, there is sufficient time for the development of enterprise practice. The BDFM project require students to stay in PEB for one and a half years, and then the students could have enough time to participate in the whole process of engineering project e.g. engineering design, engineering implementation, and engineering acceptance. The students could also solve various technical problems in the actual production process for the enterprise. This BDFM project lays the foundation for the transformation of university research and the sustainable development of enterprise practice.

C. Course Construction in Guizhou

Curriculum teaching is the most important part of realizing the educational function in PEB. In order to enable the full-time M. Eng. to carry out enterprise practice in Guizhou Province, students will systematically learn the big data theoretical knowledge, professional knowledge and cutting-edge knowledge. To achieve this goal, the project team developed a training plan for the direction of big data, including 12 courses, as shown in Table I. Each university tutor who wish to supervise a BDFM student must participate in one course in Table I, and they should also go to Guizhou Province to deliver that course. It is worth mentioning that "Big Data Discipline Frontier Hotspot" **i**s taught by more than one university tutors that come from different research subjects. Hence, the content of this course is extremely rich, covering almost all the cutting-edge issues related to big data. More importantly, this course is not only offered to the students, but also to all enterprise tutors, so that the latter can grasp cutting-edge science and technology. Another interesting course is "Guizhou Big Data Special Lecture" that is offered by more than one enterprise tutors from Guizhou Province, which teaches the students how to make full use of big data technology to solve practical problems through special introductions and case study. Moreover, students are made aware of the product development, technological transformation, production management, etc.. In addition, students can understand the development of the big data industry, and enhance their enthusiasm and initiative for learning [11]. It can be known that the designed BDFM project not only promotes enterprises to actively participate in the M. Eng. training, but also opens a bidirectional feedback between enterprise demand and university technology, which effectively bridges the gap between enterprises and universities [12].

TABLE I COURSE LIST OF BDFM

course name	curriculum attributes
Data Mining: Theory and Algorithm	basic theory course
Convex Optimization	basic theory course
Big Data Modeling and Analysis	professional basic course
Big Data Analysis	professional basic course
Fundamentals of Big Data System	professional basic course
Pattern Recognition	professional basic course
Lecture Series on Big Data Science and Application	professional course
System Engineering and Optimization	professional course
Advanced project Management of IT	professional course
Big Data Discipline Frontier Hotspot	lecture course
Guizhou Big Data Special Lecture	lecture course
Data Ethics	professionalism course

D. Establishment of Mechanism of PEB

After the PEB construction, the project team should establish a multi-dimensional evaluation system from university tutors, enterprise tutors and students [13]. The details are as follows:

Firstly, project team should establish mechanism of appointment, assessment and incentive for university tutors. On the one hand, a strict admission mechanism of university tutors should be implemented, and only qualified university tutors are allowed to supervise big data students. On the other hand, if the students trained by the university tutors have made outstanding achievements in engineering practice, then the university tutor can be rewarded.

Secondly, project team should establish a strict employment mechanism for enterprise tutors. In order to improve the effectiveness of tutoring, project team not only set up certain criteria for the admittance of enterprise tutors, but also set up a three-month pre-employment period for enterprise tutors. Only qualified enterprise tutors are allowed to supervise big data students. Reversely, students could submit application for enterprise tutor replacement during the enterprise practice if the latter could only offer poor tutoring effect. In addition, the project team is considering to establish an incentive mechanism for enterprise tutors.

Thirdly, project team should establish an incentive mechanism for students' enterprise practice after the students complete the practice, the project team organizes an evaluation for their performance and selects the outstanding individuals to award.

E. Establishment of Dual Tutor Matching Mechanism

Enterprise tutors wish to obtain the maximum economic benefits and profits in a short time, whereas university tutors are keen on the publication of papers. They often do not have a common goal of M. Eng. training. Therefore, they may go their own way, which greatly reduces the implementation effect of the "Dual Tutor System". The project team then tried to solve this unfavorable situation by searching for the best matching between the two types of tutors and giving full play to their respective advantages. The so obtained mechanism is named as the Dual Tutor Matching Mechanism (DTMM) that could integrate enterprise resources and university resources into one to optimize the resource utilization.

Professor Von Karman from California Institute of Technology ever stated that "Scientists study the existing world, while engineers create the world of future" [14]. Hence, the innovation ability is a very important property of

a qualified engineer. Fully considering the complex factors that affect the project as well as transforming the existing scientific and technological achievements into the actual industrial technology and products both need the creativity of engineers. Hence, we should respect the individual choices of students when they choose university and enterprise tutors with their own personality and interests. This could possibly cultivate the creativity of students.

After accumulating rich management experience, the project team fully realized that DTMM depends on the matching between university and enterprise tutors. In fact, DTMM should meet the requirements of three levels:

The primary level requirements seek for the common research directions between the university tutor and the enterprise tutor.

The intermediate level requirement is to check whether the enterprise needs the help from the University, in terms the talent resources and knowledge.

The advanced requirements check whether the enterprise has the demand for independent research & development and technological innovation.

After dual tutor matching is completed, the student then chooses dual tutors that are consistent with his/her own research direction and his/her personality. This process is defined as "inverted" dual tutor matching, as shown in Figure 5. Afterwards, they could obtain a better decision, which is much different from the traditional way where students have to make a choice in the very beginning. The dual tutor matching and inverted dual tutor matching both come from the valuable experience accumulated during the implementation of BDFM project. Nevertheless, the project team is continuing to improve the DTMM in the future.

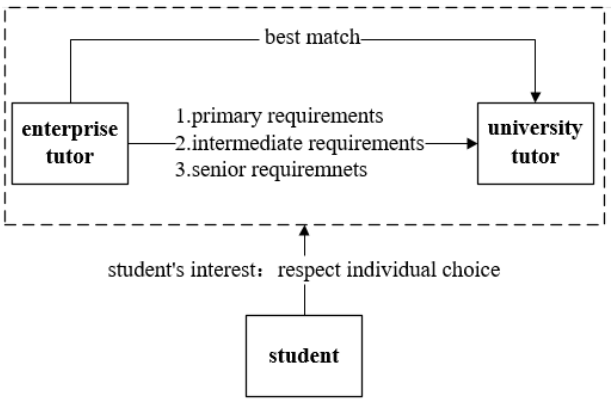

Fig.5 Dual tutor matching and inverted dual tutor matching mechanism

IV. RETHINKING ON TRAINING REFORM OF MASTER OF ENGINEERING

The project team of PBMM at Tsinghua University has accumulated a lot of experience, that can help broaden the vision for the future development of the project. Moreover, the project team carried out a timely assessment and reflection on the project.

A. Effectiveness Evaluation

By February 2020, the first 30 students in the Guizhou PEB had completed their one year's enterprise practice. In order to gain an in-depth understanding of Tsinghua University's BDFM project, the project team tracked its implementation process and then investigated the practice effects of the students.

It is found that students have gained rapid growth as well as many unexpected achievements after one year training, including class construction and academic progress. The class has also won the honorary title of the excellent class in Tsinghua University for many times. Compared with other full-time M. Eng. class located at Tsinghua University campus, the big data class in PEB of Guizhou shows stronger cohesion and combat effectiveness. Meanwhile, the scientific research achievements of the students are gratifying, as they have published 3 academic papers index by Scientific Citation Index (SCI), 6 academic papers index by Engineering Index (EI), and submitted 7 patent applications as well as 1 software copyright. Most research achievements are closely related to the direction of the enterprises. For example, they proposed intelligent analysis methods for Expressway big data and medical big data, and developed relevant application software.

It is particularly worth mentioning that the monitor of the class has rapidly grown into a student leader with excellent team management ability and good practical innovation potential. In the interview, she mentioned that "The PEB is a special campus and has shaped me to grow faster and better. In this year, although we are far away from university campus and lose the dense learning atmosphere and academic atmosphere, my classmates are unexpectedly more united than the other class. We get along with each other day by day, through organizing various activities and exchanging emotion. At the same time, we create our own learning and academic world, through organizing the academic group meeting and organizing the remote group meeting with the university tutors. More importantly, being closely involved in the process of enterprise work, we can obtain the rich practice experience that other class at Tsinghua University campus does not. We can combine the research work of the university tutors with the actual needs of the enterprise, which is the greatest advantage of BDFM. In all, we should make full use of the enterprise practice environment provided by universities, enterprises and government".

During the investigation, the project team discovered some problems in the project construction. For example, although students are centralized in enterprise, the effects of students' practices are not the same. Firstly, students' participations in corporate topics are different, and only 40% of students' topics are of key importance. Secondly, enterprise tutors and university tutors not always cooperate, and only 33% of university tutors and enterprise tutors have established project cooperation. Thirdly enterprises have different enthusiasm for student training, and only 67% of enterprise have provided effective guidance to students.

Though we have already seen the initial results from the process of PEB, there are still many issues not well solved. For example, how to better establish an enterprise-to-university feedback mechanism? How to attract enterprises with more developmental potentials to join the talent training? How to make better use of the initiative of enterprises and governments for the talent training? How to establish a sustainable development mechanism for the integration of science and education and how to establish the transformation from research to industry? Where should we focus in the future? The project team has carried out the

overall evaluation and further reflection as listed in the following subsections.

B. Establish a Platform for Scientific and Educational Innovation

After full investigation and consultation with relevant government departments, project team plan to establish a big data science and education innovation platform (BDSEP) in Guizhou Province. The local government is in charge of the BDSEP, while universities and companies will jointly participate in its construction. The BDSEP has a complete organizational structure aiming to integrate science and education, as shown in Figure 6.

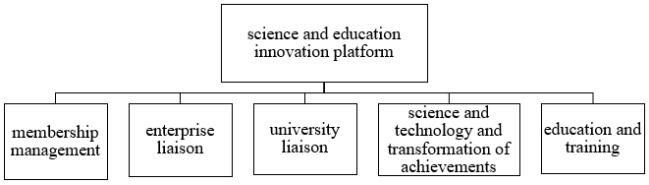

Fig.6 Function diagram of science and education innovation platform

The BDSEP should have member management functions, including establishing member access mechanism, establishing operation mechanism, clarifying member rights and obligations , etc.. Firstly, BDSEP establishes the access standard for enterprise members. Enterprises that meet the access standard could pay membership fees each year to join the platform and enjoy all the rights of membership. The injection of enterprise membership fee is the basic fund to maintain the operation of the platform. Secondly, university tutors will automatically become a member and enjoy all the rights of membership. Thirdly, enterprises who have solved the major issue through using the platform should pay a certain amount of fee to support its continuous operation.

The BDSEP should have the function of enterprise liaison. Firstly the BDSEP keeps close contact with the business community to attract more promising or excellent enterprises to join the association by organizing various activities like visiting, exchanging, seminars, gatherings, etc.. This can help improving the influence of the platform. Secondly, the enterprises could rely on the strength of university science and technology to solve the important issues related to the development of national economy. Through the liaison work by BDSEP, the enterprises' demand can be fed back to BDSEP in time. Thirdly, through the platform, enterprises can participate in various education and teaching projects of university, and constantly carry out various in-depth investigations. Hence, the enterprises could learn what types of talents they would need during the industrial upgrading period [15], and promote the establishment of partnership with universities.

The BDSEP should have the function of university liaison. Firstly the platform maintains close contact with university tutors by organizing flexible and diverse activities, such as exchanges, symposia, seminars, etc.. Secondly, through this platform, the latest scientific results of university tutors are introduced to the enterprise to help the enterprise fully understand what is the most cutting-edge science and technology.

The BDSEP should have the function of promoting the transformation of science and technology. The platform relies on experts to scientifically refine the major needs of enterprises, and the government offers the science projects to meet such needs. The platform relies on certain operation mechanism to gather the tripartite strength of U-G-E to effectively help enterprises solve major problems while promoting the transformation of university research.

The BDSEP should have the function of education and training. The platform provides all kinds of resources to the M. Eng. training, including DTMM for university tutors and enterprise tutors, merging the feedback of enterprise demand into the M. Eng. enterprise practice, and even setting up employment opportunities for students. Through the establishment of this platform, we could truly realize the perfect integration between technology and education.

In all, the BDSEP is an integration of scientific research, scientific and technological services, and talent training. It focuses on the cooperation of production, learning and research. The government will play an important role in the platform construction. The government not only has jurisdiction over enterprises, but also is the maker of education policies. Therefore, relying on the power of the government, the platform construction can obtain various supports, including local government departments, enterprises support, financial support, etc., so as to promote the cooperation between universities and enterprises from various aspects. In short, the platform will rely on the government to bridge the gap between industry and education, to make up for the lack of feedback from industry and education, and to greatly shorten the distance between enterprises and education. It provides an important support for the industry to realize the transformation of production, education, and research. It also provides the support for the academy to better train the M. Eng. talents. More importantly, it provides strong scientific and technological support for the business community to solve the major issues of national economy.

V. CONCLUSIONS

China's full-time M. Eng. education is still in its infancy [16]. In the past decade, the development of China's full-time M. Eng. education enlightened us that: as an important part of China's HEE, the full-time M. Eng. education is an complex system and undertakes the important historical mission of delivering high-level technical talents for China. However, during the development process of the first decade, China's M. Eng. education relies too much on a single force of universities, and the collaborative talent training among U-G-E has not been well established. Therefore, the effect of M. Eng. training is undesired. There are still much deficiencies in the construction of EPB, enterprise tutor faculty, and Dual Tutor System.

As practitioners of the M. Eng. education reform, the project team has witnessed the development process of the BDFM training project of Tsinghua University. We overcome various difficulties by breaking the current situation of insufficient cooperation among U-G-E, and by establishing a PEB for M. Eng. By strengthening the deep interaction among U-G-E, we can make up for the gap between the education community and the business community, promoting the integration of industry and education, and constructing integration platform of industry, education and research. Moreover, the project team tries to actively seek for the joint forces of U-G-E in the process of M. Eng. training and strives to cultivate high-level scientific

and technological talents that serve the needs of the national economy.

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