

Improving Engineers' Ability by Strengthening University-Industry Collaboration: A Plan for Education and Training Outstanding Engineers (PETOE) in China

Dr. Huiming Fan, East China University of Science and Technology

I am a lecturer from Institute of Higher Education, East China University of Science and Technology. I got Ph.D. degree from Zhejiang University in 2014. I was also a visiting scholar at the area of University-Industry Collaboration at North Carolina State University from 2012.12-2013.7. My research focuses on engineering education, university-industry collaboration, entrepreneurial university, etc.

Mr. Huaizhong Shao, Zhejiang University

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Huiming Fan^a, Huaizhong Shao^b

^a Institute of Higher Education, East China University of Science and Technology, 130 Meilong Road, Shanghai 200237, China

^b Research Institute of Development Strategy, Zhejiang University, 866 Yuhangtang Road, Hangzhou, Zhejiang 310058, China

Abstract

In order to provide more high-quality, skilled engineering workers for the construction projects of an innovative country, the Chinese government proposed “A Plan for Education and Training Outstanding Engineers (PETOE)” in 2010. One of the unique characteristics of PETOE is stressing the role of enterprise in the cultivation of new engineers. After five years of development, the plan has taken some imaginative steps, such as setting up lead agencies to guide university-industry cooperative cultivation, adjusting degree plans, cultivating programs and curriculum to enhance students' internships, building practice platforms, providing high-quality internship opportunities for students, and strengthening the qualifications of teaching staff to improve teachers' ability to guide engineering practice. These practices have achieved some success. However, some issues still exist in the plan, such as a lack of business initiatives in personnel training, insufficient guidance initiatives for teachers, barriers to the consistent expansion of PETOE pilots, and a lack of inter-institution cooperation between different degrees across universities. At the end of this article, some suggestions are put forward to be considered at the university, enterprise, and government levels.

Keywords: PETOE, China, engineering education, university-industry collaborative cultivation, engineering internship

Introduction

In 2008, the NAE (National Academy of Engineering) released a report named “Grand Challenges for Engineering in the 21st Century,” in which 14 major engineering challenges facing mankind in the 21st Century were presented including the economic use of solar energy, the development of hydrogen energy, the development of advanced medications and therapy, maintaining the supply of clean water, etc.¹ U.S. universities have jointly launched “Grand Challenges Scholars Programs” to recruit and train innovative engineers in order to respond to these challenges. After more than 30 years of rapid growth, China faces the pains of industrial and economic restructuring: in the meantime a new round of technological and industrial advances offers the best opportunities for Chinese economic development. But China is also facing a lack of creative engineering professionals who can drive the development of new industries.

To fill this gap, the Chinese Government put forward a nationwide program known as “A plan for Education and Training Outstanding Engineers (PETOE).” The goal of this engineering-focused higher education reform is to improve students’ social responsibility in terms of serving the nation, courage to explore creative ideas, and practical ability to solve problems². University-industry collaboration is a unique characteristic of PETOE and a key factor for further implementation of this program, because university-industry collaboration can enhance the inventive and practical skills of engineering students at the same time.

The importance and necessity of developing engineers’ abilities through university-industry collaboration

Cultivating engineers through university-industry collaboration is an important model or method in the engineering world. The earliest educational example of

combining work with study can be found in the “sandwich” model created by Sunderland Technical College in 1903, which required students to complete theory learning, industry practice phases to deepen students’ understanding and awareness of industry practices by alternating between learning and practice. In 1906, the University of Cincinnati united a few large enterprises and created a “working and learning alternation” model, and the United States began to implement the “cooperative education” model in 1921³. This was followed by the subsequent emergence of Singapore’s “teaching factory” model and Canada’s “university-industry cooperative education” model⁴. All of these have proven that the involvement of industries and enterprises is an important part of cultivation of engineering workers. From the perspective of international engineering education experience, enterprises play an important role in fostering students’ innovative, practical, and problem-solving abilities through participating in the development of training programs, curriculum and teaching, internships, graduation, and other areas. With the development of China's market economy, the concept of training industry-oriented skills is recognized by universities and the community. Engineering skills training in colleges and universities also increasingly relies on private enterprises. Thus, in recent years the Ministry of Education and China's colleges and universities have carried out many university-industry collaborative explorations to enhance cultivation of talented workers. These programs have achieved some success and internship has been an important part of engineering skills cultivation.⁵ However, compared with the ideal target, cultivating engineering talent through university-industry cooperation still has some problems. Particularly, surveys in the industry often indicate that new engineering graduates are lacking practical ability, adaptability, innovative spirit and ability, teamwork and professionalism, etc.⁶ These problems could have been better addressed through university-industry cooperation, but imperfect policy, old ideas, enterprises’ negative participation, vague content of cooperation, and inadequate relationships between schools and management still plague the cooperation between universities and enterprises⁷. The natural differences between universities and private enterprises are the main reasons. From the perspective of interest-seeking, the university attempts to

cultivate students but enterprise aims at getting a cheap labor force and recruiting the right employees. From the perspective of time arrangement, the university arranges curriculums and internships based on strict timetables, and temporary adjustment is difficult. However, the internships arranged by companies are uncertain: in most cases they will take into account the actual situation of production, sales, etc., which may cause interaction between universities and enterprises on the internship arrangements. From the perspective of benefits to organizations, universities pursue internships which can improve students' abilities and private enterprises have the responsibility for student safety, but due to the flexibility of employment, enterprises cannot force the students to work there after their internships. This can cause an imbalance between enterprises' investment and benefits⁷. In other words, the companies can sometimes put more into an engineer in training than they get out of him. The above reasons cause difficulties in cultivating engineering talent through university-industry collaboration.

Therefore, allowing corporations to be more involved in engineering students' education and to play a necessary role in all aspects of training are important ideas to solve the problems associated with university-industry collaborative training. PETOE is an active exploration implemented by the Ministry of Education to enhance the students' innovation and practical ability through strengthening university-industry cooperation.

The introduction of PETOE

Before the implementation of PETOE in 2010, the Chinese government made several strategic plans for the next 10 years (2010-2020) or even longer. The three most important initiatives are "a new path of industrialization with Chinese characteristics," "building an innovation-oriented country," and "construction of a country with strong talent resources"⁸. Implementation of these strategies and goals will depend on the strong support of engineering science and technology personnel. The country's future engineers must have a strong capacity for innovation and the ability to solve complex problems to meet the needs of economic and social development in the new era.

Sustained demand for high-quality engineering talent placed new pressures on China's higher engineering education resources. The implementation of PETOE is an important strategy for China's ongoing reform of higher engineering education to adapt to national development and service needs.

In June 2010, the Ministry of Education held the first meeting for PETOE at Tianjin University, which marked the beginning of the project. At that meeting, a total of 61 Chinese universities were selected as pilot universities for PETOE. In 2011, another 133 universities were selected. By 2013, the number of students participating in PETOE had reached 130,241, and the funding reached 221,227.36 million RMB⁹. The goal of the project is that by 2020, 10% of all the engineering undergraduates in the country will be part of the program, and 50% of engineering program graduate students will be in the program¹⁰.

Table 1: the number of students and funds of the project according to various types of universities

University type	the number of colleges and universities	the number of students	the amount of funds (10 thousand RMB)
“985” university	27	55,011	72,906.12
“211” university	38	31,386	65,275.02
Ordinary undergraduate colleges	110	36,876	73,017.89
Newly-established undergraduate colleges	19	6,968	10,028.33
Total	194	130,241	221,227.36

Data Source¹¹: Lin, J. 2012. The Whole Cooperation Process Between Universities and Enterprises on Training Outstanding Engineers. *Research in Higher Education of Engineering* 03, 7-23.

In the official document “Several Opinions from the Ministry of Education on the Implementation of a Plan for Education and Training Outstanding Engineers” (Department of Higher Education, Ministry of Education [2011] No. 1), the Ministry of Education describes the main objectives of PETOE as “cultivating a large number of

various types of high-quality engineering and technical personnel with innovative ability for the industry, for the world and for the future to adapt to economic and social development needs, laying a solid human resources foundation for the construction of an innovative country to achieve industrialization and modernization, enhancing our core competitiveness and overall national strength.” In terms of specific levels of cultivation, the project works with undergraduate and graduate engineering students. In terms of cultivating types, Engineering and education expert Zuo Tiejong from the Chinese Academy of Engineering lays out five types of engineers that China will need for its future. They include professional technical engineers who are excellent at solving real problems, research-oriented engineers who have expertise in research and development, integrated innovation engineers who are excellent at cross-application of different disciplines, innovative design engineers focusing on innovative design, and operation and management engineers focusing on entrepreneurship and marketing¹².

Table 2 PETOE cultivating objectives, levels and types

cultivating objectives	Industry-oriented		World-oriented		Future-oriented
cultivating levels	Ph.D. students				
	graduate students				
	undergraduate students				
cultivating types	Professional technical engineer	Research-oriented engineer	Integrated innovation engineer	Innovative design engineer	Operation and management engineer

Source: Zuo, T. 2010¹². The Speech of Zuo Tiejong in the Starting Meeting of A Plan for Educating and Training Outstanding Engineers . Downloaded on 10 Dec. 2015 from <http://xdw.swjtu.edu.cn/ShowNews-4121-1.shtml>

PETOE proposed the concept of industry-oriented training, and greatly emphasized the role of private enterprises in engineering talent cultivation when developing and implementing the plan. The plan has three distinct characteristics: first, the industry and enterprises are deeply involved in the cultivating process; second, the university trains engineering students according to common industry standards; and third, the cultivation of students’ engineering and innovative abilities is strengthened. As the competent

authority, the Ministry of Education takes five measures to promote enterprises' deep involvement in PETOE. First, it creates a new mechanism for university-industry collaborative cultivation. Enterprises become joint training units as opposed to taking a simple role as employer: they work with universities and industry designing objectives, developing cultivating programs, and collaboratively implementing the cultivating process. Second, the Ministry reforms cultivation models to focus on strengthening engineering capabilities and innovation abilities. The plan sets up a number of national "Engineering Practice Education Centers" in companies and enterprises, and students can study and finish their graduation projects in these enterprises. Third, it reforms and improves the engineering teachers' appointment and appraisal system. The evaluation of engineering teachers must be based on project design, patent, industry cooperation, and technical service, and the persons who have industry experience are more welcomed to be engineering teachers. Fourth, it opens wider access to the outside world. The Chinese Scholarship Council should give priority to support teachers and students to carry out international exchanges and internships abroad. Fifth, the ministry collaboratively develops student cultivating standards by universities and industry. The Ministry of Education and the Chinese Academy of Engineering jointly develop common standards, the Ministry of Education and private industry jointly develop professional standards, and universities train students according to both of the standards. The quality of engineering students will be evaluated according to the international standard².

Some practices of PETOE from pilot universities

According to the Ministry's proposals and deployments, universities have carried out reforms on university-industry cooperative cultivation with different characteristics.

Setting up lead agencies to guide university-industry cooperative cultivation

In order to ensure the effective promotion of PETOE, universities set up organizations in coordination with enterprises, and the organization is normally named

the “University-Industry Cooperative Steering Committee.” The mission of these organizations is to guide and supervise PETOE and ensure the realization of the objectives. The Steering Committee emphasizes the broad participation of enterprises and industry experts. For example, Tianjin University has established the Teaching Steering Committee at the university level, which requires that no less than 50% of the experts should come from industry and companies. They can be chief engineers or directors of technology in multinational companies at home or abroad. The goal of the committee is to promote the development of PETOE and carry out two types of responsibilities according to the tightness of university-industry collaborative cultivation. The first function is mentoring. The committee should review new training programs, guide new reforms on cultivation models and curriculum, promote the construction of practice bases, and help with analyzing issues of university-industry cooperation. The second function is deeply involved in university-industry collaborative cultivation. The committee represents the interests of both university and industry, and the engineering talent will be recruited through the decision of the committee. For example, the Zijin Mining Company invested 150 million RMB to build practice teaching bases for the students majoring in resource exploration engineering, mining engineering, and mineral processing engineering at Fuzhou University. The School Board was set up to ensure that the enterprise is deeply involved in the student training process, such as the disciplinary construction and development of the college, specialties settings, talents cultivation, university-industry interaction, college funding, etc. The company has the authority to make decisions on all of the above matters.

Adjusting degree plans, cultivating programs and curriculum to enhance students' internships

According to the requirements of new talent-cultivating standards in PETOE, university and industries must begin to adjust their degree programs, cultivating programs, and curriculum at the same time.

In terms of degree programs, some universities are trying to explore a consecutive

program among bachelor's, master's and doctoral levels to meet the demand for cultivating innovative engineering talent. Its main idea is breaking barriers between different degrees, reducing duplication of training, and providing more time for students' internships. For example, Southwest Jiaotong University sets up degree programs in a "4+2+3" model and a "4+4" model to integrate bachelor's, master's, and doctoral levels. This model can break the boundaries of different degrees, and the overall design of degree programs across three levels can contribute to the strengthening of students' basic knowledge, innovation sense, research ability, and practical ability, etc. In addition, this university also has set up a "4+2" degree program to integrate the bachelor's and master's levels, and this type of degree program emphasizes the understanding and grasp of practical engineering knowledge. In its first three years of cultivating arrangements, the program emphasizes the study of basic theories and knowledge of related engineering fields. In the fourth year, the studies of the undergraduate and postgraduate stages will be connected together. The postgraduate courses, undergraduate project design, and internships will be arranged in the fourth year of the undergraduate level, so the students can have more time to do internships in both undergraduate and graduate levels.

In terms of cultivation or training programs, the new cultivating program also focuses the model of university-industry collaborative cultivation on the needs of student internship. The collaborative models can be divided into two categories. The first category is a "theoretical study before internships" model, such as the "3+1" model. In this model, the students will study at university for the first three years and do private enterprise internships in the last year. For example, Xi'an University of Science and Technology arranges for students to complete study in the enterprises in the seventh and eighth semesters. The student should finish courses related to enterprises' actual operation, be familiar with the enterprise, start pre-job training, develop career plans, etc. in the seventh semester, followed by the post practice in the eighth semester. The post practice will be viewed as an important part of the students' graduation project assessment. The second category is "intersection of theoretical study and internships"

model. For example, the “2.5+0.5+0.5+0.5” model requires the students to study at the university from the first to fifth semester, do internships in the sixth semester, then study in university in the seventh semester, at last practice in enterprises in the eighth semester.

In terms of curriculum setting, courses with the participation of industry increases, and gradually becomes compulsory courses instead of optional courses. For example, Dalian University of Technology has set up nearly 100 courses with private enterprises including “Enterprise Culture,” “Enterprise and Production Management,” “Project Design and Practice,” “Principles of Steam Turbines and Equipment,” “Introduction to Nuclear Engineering.” In addition, the enterprise has open seminars and cutting-edge technology lectures for students. These courses and lectures strengthen the students’ understanding of the operation of enterprises and engineering practices, and help them integrate themselves into the enterprise and engineering projects in the follow-up practice.

Building practice platforms and providing high-quality internship opportunities for students

The practice platforms for students are mainly divided into three types: the first type is “engineering practice education centers,” the second one is “university-enterprise joint laboratory” and the last is “university-enterprise union.” The first type is an important innovative practice of PETOE. These elaborate practice platforms will not only provide high-quality internship opportunities for students, but also ensure a long continuous internship for students.

As pointed out in the official document “Several Opinions from of the Ministry of Education on the Implementation of a Plan for Education and Training Outstanding Engineers” (Teaching High Department of Higher Education, Ministry of Education [2011] No. 1), universities and enterprises should build engineering practice education centers which should be charged by the key managers of enterprises. Engineering practice education centers are a critical point of implementing joint

training between universities and enterprises. In practice, each of the pilot universities has established more than one engineering practice center within the enterprises involved. Some of these practice centers are approved by the Ministry of Education, while most of them are approved by the provincial government or the various universities themselves. At the same time, these practice platforms lay a solid foundation for the training of excellent engineers and the improvement of students' practice abilities.

In contrast with previous university-enterprise joint laboratories, the laboratories under the PETOE model have the function of internship and practice, so students can gain practice experience in the university instead of practicing in enterprises. For example, in cooperation with Japanese Mitsubishi Motors, Tianjin University has built a brewing and canning production line which has typical characteristics of industrial production. This experimental platform with the function of teaching, professional training, and scientific research provides hardware support for the improvement of practice ability.

Moreover, constructing a university-enterprise union can also provide internship opportunities for students. The university-enterprise union is constructed by a number of universities and enterprises, so there are more choices for students to find an internship. For example, Tianjin University and China Internal Combustion Engine Industry Association established a "Technology Innovation Alliance of Energy Saving Combustion Engine" which includes nine automobile and engine companies and seven universities. The alliance not only jointly researches key technologies, but also organizes academic meetings and provides many opportunities for students.

Strengthening the training of teaching staff to improve teachers' abilities in engineering practice

The core concept of the improvement of teaching staff is to enhance teachers' business experience, awareness, and abilities in terms of engineering practice, all of

which can help students to achieve significant progress in engineering design, innovation, and practice. In sum, universities should strengthen the training of teaching staff from different perspectives.

First of all, it is greatly important to strengthen the qualifications of full-time teaching staff in engineering field. Teaching staff equipped with theoretical knowledge as well as practical ability is the indispensable basis for training excellent engineers. Currently, Chinese engineering teachers are generally equipped with the system of engineering theories, but they are sometimes lacking in ability of engineering practice. Therefore, many universities have made a great effort to enhance teachers' practical abilities. First, in many universities, engineering internship experience is a requirement for teachers hoping for a promotion or who wish to be an instructor. For example, the provisions of Tianjin University set out that engineering teachers who want to be promoted to associate professor from the position of lecturer, or promoted to professor from associate professor, should have more than one year of experience in enterprise engineering practice. In addition, engineering teachers in Tongji University should be subject to at least one and a half years' pre-job training (that is, to be an assistant for professors in the university for one year and complete the practice projects in private enterprises for six months). Secondly, universities have adopted a series of incentive policies to encourage teachers to participate in internships. For example, engineering teachers in Southwest Jiaotong University who attend a training practice can have the option of taking on fewer teaching tasks after passing the examination. What's more, Xi'an University of Electronic Science and Technology provides some rewards for the outstanding young teachers who enter enterprises to gain internship experiences. Fuzhou University provides special funds for sending teachers to participating enterprises. Finally, new teachers are required to have a certain number of years of experience in engineering practice at the time of recruitment. For example, Xi'an University of Electronic Science and Technology requires that new full-time teachers should have more than five years of working experience in enterprise. Tongji University has made it a priority to hire teachers having part-time work experience in enterprises

in order to increase the proportion of teachers with engineering experience. These measures have largely solved the problem of the teachers lacking engineering practice skills.

Moreover, it is important to strengthen the qualifications of part-time teaching staff in engineering field. Universities should recruit engineers with rich experiences in business as part-time teachers, whose obligations include participating in curriculum teaching, guiding students to carry out a graduate project, and receiving engineering training. Engineers in enterprises have extensive experience in practice, so they can effectively guide and help students master engineering skills, as well as enhance their practical ability. For example, the joint venture agreement between Southwest Jiaotong University and private companies suggests that enterprises should arrange for staff with extensive experience in engineering projects to be part-time teachers in universities. Every tutor from industry should co-supervise 1-2 students with faculty. What's more, each major under PETOE in Dalian University of Technology has appointed about ten part-time teachers and has presented their duties, including participation in training project, the formulation and revision of curriculum system and training program, the development of relevant courses, and responsibility for internal and external experiments.

Issues emerging in PETOE

The number of students practicing in enterprises has increased a great deal since PETOE was first introduced. From 2010 to 2012, 6,247 enterprises participated in PETOE. PETOE has significantly enhanced the role enterprises are playing in engineering education. However, there are still some issues that exist in personnel training through university-industry cooperation.

Lack of enterprise initiatives in personnel training

Obtaining the expected return is the main motivation for enterprises to participate in engineering students' training. These expected benefits may include obtaining advanced technology coming from universities, using cheaper student labor, finding and recruiting suitable graduates, and gaining policy incentives from government. Nevertheless, in practice, enterprise earnings have not been effectively protected. The limited knowledge of the students cannot bring advanced technology to enterprise continuously. Also, the government attaches great importance to the safety of students, which sometimes makes enterprises nervous about using student labor. Enterprises may need to buy some insurance for the students, which brings extra expenses to the business expenditure. Besides, even if the enterprises involved find excellent graduates that they want to hire, they have no rigid protocol that can constrain students to stay in the enterprises. The government has so far not introduced initiatives such as tax breaks or subsidies to encourage enterprises to receive student internships. The current university-industry cooperation in personnel training is more dependent on complex alumni, teacher-student relationships, leadership exchanges, and other non-organizational factors (Lin Jian, 2012). The university-industry cooperation in talent training is difficult to sustain if the interests of enterprises cannot be effectively protected.

Lack of teachers' initiatives in guidance

PETOE requires engineering teachers to have theoretical knowledge and experience in engineering practice. The current teacher evaluation system of Chinese universities can be hard to change. Teachers are reluctant to spend too much time increasing their experience and giving guidance to engineering students in internships because universities emphasize the amount of papers published and projects applied rather than guidance of internship students in their current evaluation systems. These factors also account in terms of job promotion during teachers' careers. In the absence of implementation of the classification evaluation of teachers, anyone who wants to be a teacher wants to have an outstanding performance of teaching and research. Instead,

they are reluctant to be promoted for their good practice in engineering and guidance to internships, which may make it seem that a teacher is not as good at academics.

Barriers to the persistent expansion of PETOE pilots

The goal of PETOE is that the percentage of undergraduate engineering students participating in the program reaches 10%, and 50% for postgraduates. In 2010, there were 3.71 million full-time undergraduate students and 0.47 million postgraduates majoring in engineering (Ministry of Education, 2010). According to this data, there should be nearly one million engineering students practicing in enterprises, excluding those who practice before graduation. The logistics of arranging so many students in long-term enterprise internships turns out to be a problem for PETOE. On the one hand, because of the lack of mechanisms to force enterprises to participate in PETOE, it is difficult to continue to maintain this non-profit-driven university-enterprise cooperation. Companies may offer fewer internship opportunities to universities in the future. On the other hand, PETOE is now funded by universities and enterprises themselves, which means it may bring financial problems to universities. There is no financial support coming from the relevant ministries and local governments.

Lack of inter-institution cooperation between different degrees across universities

In order to arrange the university's time more effectively and to provide more time of internships for students, some universities break the limits of different levels of degrees. The models of "4+2+3," "4+4" and "4+2" and some other teaching models mentioned above are accepted in many universities, which have enjoyed good results. However, the ensuing problem is that not all the undergraduates choose to study in the same university for their master's degrees and other postgraduate degrees. The teaching models we mentioned are confined to the universities internally. Achieving inter-institution cooperation and reciprocity for students' different levels of degrees across universities is one of the urgent problems that PETOE needs to solve in the future.

Future development proposals

Based on the above analysis, we should promote university-enterprise collaborative efforts cultivating engineers in four dimensions, namely: benefits, ideas, goals, and actions. Synergy of interests (or benefits) is the basis and prerequisite of the other three levels together, because common interest has not yet been achieved by collaboration between university and enterprise, which leads alienation in terms of the ideas, goals and actions of each party. Based on the above logic we made a number of suggestions for universities, enterprises, and the government, so as to encourage universities and enterprises to achieve collaboration in benefits, ideas, goals, and actions.

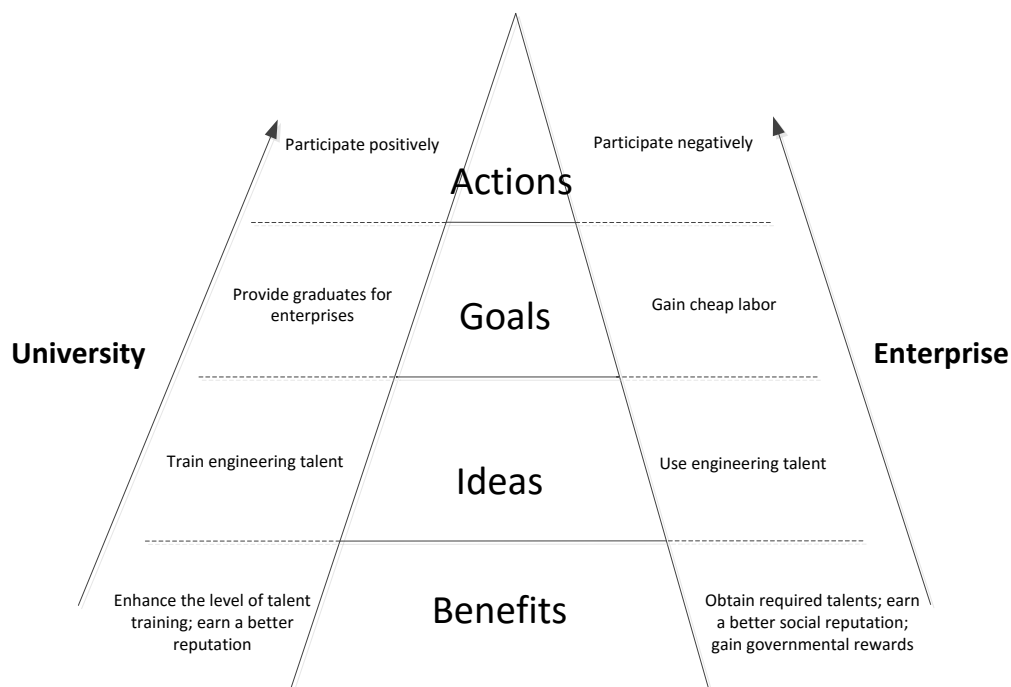


Figure 1: Differences and collaboration between universities and enterprises in benefits, ideas, goals, and actions.

Suggestions for universities

Adjust systems of teacher evaluation and promotion

Although there have been universities that viewed guiding students to participate in internships as a reference point for teachers' performance evaluations, it is not

considered as important as traditional teaching and scientific research, and almost does not work in the technical post promotion. Guiding students into practice is time-consuming work and is bound to cut into teachers' teaching and scientific research time. In the future reform, we should increase the importance of internship guidance in teachers' evaluation and the technical post promotion. Of course, we do not recommend to universities that they set up special "engineer" teachers to guide students to participate in internships, because we believe that the engineering teacher in a modern university should be both theoretical and practical; "engineer" teachers are not enough to gain a foothold in the university.

Establish university alliances to achieve inter-institution articulation of the different degrees across universities

On this question of continuity in the different levels of degrees across universities, we recommend that universities should establish university unions with "downstream" and "upstream" universities, and the union can be constituted by two or more universities. Its aim is to extend students' practice time, and the students' internships would not be interrupted at undergraduate level even if they pursue a master's or doctoral degree at other universities. On the other hand, the union will admit students' internships at the bachelor's or master's stage, so the students do not need to repeat low-level practice in higher learning stages, so as to adjust the time for students to carry out other practices or theory learning. In basic forms, "3+3" mode can be used for recommending graduate students, and "4+2" mode for normal graduate students.

Take full advantage of Alumni resources to increase internship opportunities

Taking advantage of alumni resources is one important way to solve the problem of the short supply of student internship jobs. Each university has a certain number of alumni in various industries, and some alumni may have been corporate decision-makers and leaders. Visiting and persuading alumni to provide internships for students is one of the feasible ways. Of course, this method can only be a supplementary means,

and the university cannot rely only on this method long-term. It is critical, therefore, to build excitement in private enterprise to increase internships.

Suggestions for enterprises

Update the concept of collaborative cultivating and enhance the initiatives to participate in cultivation of talent

Enterprises need to update concepts and rediscover the meaning of participation in talent cultivation. First of all, enterprises' participation in cultivating of engineers is an expression of social responsibility. For private companies, fulfilling their social responsibilities is as important as improving product quality. Collaborative talent cultivation is also an important way to improve a corporation's reputation. Enterprises may make some sacrifices temporarily, but this investment in the future also will play a positive role in promoting the enterprise's social reputation in the long-term. Second, enterprises often reap most of the rewards and experience few of the disadvantages involved in cultivation of engineering talent. Although they are unable to force all the students to remain in enterprises where they received training, enterprises can persuade many of them to stay, they gain the use of cheap labor, and may even get some advanced technologies from universities. Therefore, companies should actively embrace PETOE, and try to be an important member of it, not just as an unimportant supporting actor involved in the plan.

Expand the scope of cooperation and send staff to training in the university

In order to obtain more equal benefits and sharing of costs and risks, the two sides can expand the scope of cultivation of engineering talent. To assign students to do internships may cause the result that the university benefits outweigh the enterprises' benefits, and this will reduce the company's enthusiasm. As a remedy, the enterprise can try to compose a class of employees to receive free theoretical trainings from universities to balance both sides of costs and benefits.

Suggestions for government agencies

Propose new incentive policies and institutions

From the example of PETOE we can see that, although the Ministry of Education as the lead government department in the program made many principle opinions and suggestions, there were no substantive incentives or institutional innovations. To encourage more enterprises to participate in talent cultivation, we suggest that the government can at least take the following initiatives. First, the government should give a certain degree of tax relief or tax concessions to the enterprises which accept student internships. Second, it should give special consideration to the enterprises accepting student internships when selecting high-tech enterprise or government-support research projects. Third, it should offer some financial assistance to those enterprises that transform university technology.

Increase government funding

So far, the funding for PETOE mainly comes from universities and enterprises. Although it is a government-sponsored plan, PETOE rarely gets financial support from government, which is obviously unreasonable and is one of the important reasons why this plan is retrogressive. In the implementation process in the future, the government should invest funds and actively work to promote PETOE. The government should be at least active in the following two aspects: providing basic work-related injury insurance for student internships, and providing financial support for PETOE in accordance with the allocation of education funding.

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