

A Training Model of Out-standing Engineers: Exploration of School-Enterprise Cooperation Based on Technology Competition*

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University can build practice platforms by cooperating with enterprises, and carry out technology innovation activities through technology competition. This is an effective way to promote the personnel training system reform and to implement the “Out-standing Engineers education and training plan”. The article analyzes the domestic and international research status, and puts forward a novel competition model based on school-enterprise cooperation, which includes: building technology competition platforms through school-enterprise cooperation; opening proposition around the industry/enterprise requirements; enterprises participating in the evaluation of technology competition; enterprise-oriented talent pool construction; and the industrialization of outstanding works. Through a case of “Up-tech Cup” National Undergraduate Embedded Design Contest, the application of the above model is elaborated. We analyzed the effect of technology competition based on school-enterprise cooperation from the satisfaction survey of students, enterprises, and university. Technology competition based on school-enterprise cooperation effectively promotes the reform of personnel training system and the implementation of “Out-standing Engineers education and training plan” in China. It has certain academic value and application value for holding technology competition and implementing the “Out-standing plan”.

Keywords: Out-standing Engineers education and training plan; technology competition; competition model; school-enterprise cooperation

1. Introduction

China has become a large engineering education country. However, its engineering education is big but not strong, many but not perfect, generally lacks innovation and practicality. The evaluation system orients heavy attention on paper, and makes light of design and practice. This problem has stayed unresolved for a long time. In contrast to the United States and Europe, the “scientific” trend of the current engineering training mode is becoming increasingly apparent in China, and the personnel training cannot accord with the social needs of industries. How to reform the personnel training mode according to social needs and practical background? It has aroused great concern of Chinese Ministry of Education and universities.

In accordance with the present education situation, Chinese Ministry of Education launched “Out-standing Engineers education and training plan” in 2010. The plan is a significant reform project to implement “the national long-term education reform and development plan framework” and the “national long-term talent development plan framework”, and also to promote our country towards a powerful engineering education country. The plan is to train a large number of high-quality

engineering talent who can adapt to economic and social development needs for China. “Out-standing Engineers education and training plan” functions well in the personnel training to face the social requirement, and for comprehensively improving the personnel training quality.

In accordance with the problems of engineering education in China, it is very important to start “Out-standing plan” to solve the education problems. There are over one hundred of colleges and universities nominated for carrying out the “Out-standing plan”. Our university has become a pilot school in 2011. How to effectively implement the “Out-standing plan”? What can be done to help us not live up to the expectations of the country? It has become an important education and teaching target. This subject aims to the currently hot and difficult education problems, and regards technology competition based on school-enterprise cooperation as the starting point, and put it into practice through the “Up-tech Cup” National Undergraduate Embedded Design Contest. How to introduce school-enterprise cooperation in technology competitions? How to develop a diversified, deep cooperation, and to institutionalize the technology competitions? What is the training effect of “Out-standing engineer” through technology competi-

tion? The solutions of these problems and their practical effect not only have values to organize other competitions, but also have important academic and practical values for brother colleges and universities.

2. Domestic and international research status

2.1 Research status of domestic university

Since the “Out-standing plan” was launched not long ago, domestic colleges and universities are still at the exploratory stage. The related research reports and literature are also limited. This shows that domestic research on this subject is still in its infancy.

First, we should be clear of what is the connotation of out-standing engineer? In other words, which basic qualities and capabilities out-standing engineers should have? Paper [1] mentioned in the seminar that, out-standing engineers should have the following basic qualities and capabilities: a strong sense of professionalism and sense of social responsibility, a strong desire for knowledge and indomitable spirit of study, keen observation and analysis capabilities and efficient self-learning ability, a broad perspective and wide knowledge, a solid theoretical foundation and skilled expertise, good skills in using information and design tools, and good social communication skills and team spirit, positively tracking the latest developments. In addition, out-standing engineers should also understand professional knowledge of laws and regulations.

Second, on the implementation of out-standing engineers plan, the universities invariably select joint training based on school-enterprise cooperation as an important measure, which indicates that the combination has become an important direction for the personnel training reform. For example, [1] proposed a specific form of school-enterprise cooperation: First is the government-led out-standing engineers plan, second is open proposition competition characterized by school-enterprise cooperation, third is the social practice and production practice. We believe that, technology innovation and technology competition based on school-enterprise cooperation are also an effective way to reform the university innovation ability cultivation system, and to carry out the “Out-standing plan”.

Third, some colleges and universities are exploring the way of out-standing engineers cultivation in the process of technology competitions. [2] proposed an innovative ability training method in school-enterprise cooperation model: In the theoretical teaching process, they encourage students to creatively learn by the way of the project team;

Teaching reform is carried out through cooperation with enterprises; They organize students to participate in technology competition through cooperation with enterprises; They set up research and innovation base through cooperation with enterprises. However, the article lacks specific descriptions of these ways, and has no appropriate implementation case. We believe that, out-standing engineers can be trained through a variety of ways: Students participate in teachers’ research projects, and bear a part of work; Students are organized to participate in the national or provincial technology competition; Students choose competition topics independently under the guidance of teachers; Students participate in national, provincial or colleges’ practice project; Students undertake independently R&D project of company, and so on.

Fourth, some domestic colleges and universities are actively studying the school-enterprise cooperation mechanism based on technology competition, and have proposed a number of measures. For example, [3] proposed that the school-enterprise cooperation mechanism based on technology competition should include the following aspects: Colleges or universities organize technology competition cooperated with enterprises; Enterprise standards lead the technology competition standard; They actively introduce the latest equipments of enterprises to support technology competition; They employ the technology personnel of enterprises to participate in the evaluation of the technology competition; They encourage enterprises to carry out recruitment in the technology competition scene. But in these articles, we did not see the pilot report and effect of these measures.

Fifth, our school has done some preliminary research and pilot in technology competition based on school-enterprise cooperation. We have organized “Up-tech Cup” National Undergraduate Embedded Design Contest for many years, and guided students to receive many awards in the competition. We proposed the interactive model of “students’ competition—technological innovation—teachers’ research” in the teaching reform project. Students’ competition is combined with teachers’ research to encourage students to actively participate in technology competition. We helped students understand the professional development direction, key technologies and latest information when they had just entered the school. We helped them establish a complete knowledge system from a professional perspective. We selected outstanding students to take part in competition and research in their higher grades of study, and so on. These measures not only improved students’ interest, but also developed their innovative and practical ability.

2.2 Research status of foreign universities

In the early 20th century, universities of the United States studied the experience of higher education in Germany, and further developed it. Since then the USA became stronger and more powerful. Former Soviet Union and the relevant countries put researches in the Academy of Sciences, and artificially separated researches from universities, then colleges became a mere training institutions, and research was entirely undertaken by the Academy of Sciences. It is really not a good system from the perspective of the remaining issues. The separation of teaching and practice cannot maximize students' talent [5, 6], while the development of the world just need this talent. The successful experiences of overseas' research universities have shown that scientific practices and innovative talents can complement each other and promote each other [7–9].

Professor Gerhard Casper, former president of Stanford University believed that [10], in the long run, academic issues in any field, can achieve real prosperity only if the students actively participate as soon as possible. While the fundamental factors of creating high-level American universities is to give young students opportunities. Students can have a deep understanding of practice through their participation in the technology competition. It can cultivate an open mind and a keen interest in technology competition, which thereby are transformed into innovation activities.

In summary, technology competition based on school-enterprise cooperation is an effective way to train out-standing engineers, and the research and pilot of this model are an important and worthy exploration work.

3. Competition model based on school-enterprise cooperation

Technology competition is an important force to promote teaching reform, an important indicator of teaching level, an important carrier to cultivate students' creative ability. Technology competition provides students with opportunities for deep practice, and provides a platform for the selection of outstanding students.

Paper [3] suggested that, the mechanism of technology competition based on school-enterprise cooperation is an important aspect of the institutionalization of technology competition. Schools can carry out diversified, deep cooperation with enterprises. The key of this mechanism is that the school-enterprise cooperation model should meet the interests of the schools, enterprises and students, and forms a win-win profit-driven mechanism. Technology innovation and technology competi-

tion based on school-enterprise cooperation are also effective ways to carry out the "Out-standing Engineers education and training plan". Owing to our organization experience of technology competition for many years, we propose a school-enterprise cooperation model based on technology competition, and elaborate from the following aspects:

3.1 Build technology competition platforms by school-enterprise cooperation

The competition platform construction is an effective way to deepen the school-enterprise cooperation. Both sides rely on this opportunity to carry out deep cooperation in personnel training and achievement sharing. Enterprises bring the most advanced equipment, technology and training system to universities, and carry out comprehensive cooperation in production, teaching, learning and research. Therefore a win-win goal can be achieved between universities and enterprises.

3.2 Open proposition around the industry/enterprise requirements

The proposition of competition uses open proposition around the industry/business needs. But the details, such as product technical specifications, knowledge involved, have no specific requirement. This form of proposition prompts students to closely follow the development of society and industry, and helps them integrate theory with practice, as well as help enterprises provide ideas and select talent. This form also gets rid of the embarrassing situation of traditional electronic design contest, that universities are heat, enterprises are cold. In open proposition competition, students get rid of the shackles of the old rules, and can maximize divergent thinking to create imaginative works. Open proposition competition creates an innovative atmosphere and environment, which encourage students to get rid of the habit of completing the assigned task and following the intrinsic routines. It helps to form divergent thinking and innovative thinking.

3.3 Actively introduce the latest products of enterprises

Technology competition and students' innovation activities need the support of equipment and funding. On the other hand, enterprises want to promote their products and devices so as to expand their impact. Enterprises also need to transform their outstanding achievements of technology competition into productions as soon as possible, which can improve the competitiveness of enterprises. In this way, schools, enterprises and students can achieve win-win, so the innovation activities of students can develop deeply.

3.4 Invite enterprise experts to participate in the judgement of technology competition

In the judgment of technology competition, not only university experts, but also enterprise experts are needed. This is the need of establishing a diversified assessment team. Enterprises or sponsors participate in competition in order to achieve their business goal; their short-term and long-term goal is for the development of enterprises. At the same time, in competitions, the device and products of enterprises are often used. Because the enterprise experts are very familiar with the device configuration, performance, operation, they can propose practical advice, thereby enhancing the judgment level and judgment quality of competition.

3.5 Enterprise standards leading competition standards

“Out-standing Engineers education and training plan” advocate enterprise oriented. Technology competition is closely combined with the latest standards of the industry. First, relying on industry association, the overall policy decision and program of technology competition are provided. Second, enterprise technical experts are invited to participate in making propositions of technology competition, so the requirements of modern enterprise employees are integrated into competition to examine student’s actual ability. Third, enterprise technical experts are hired to participate in the assessment and evaluation, which fully reflects the latest technical requirements of the industry.

3.6 Enterprise-oriented talent pool construction

The outstanding players in competitions are favored by many enterprises. Some enterprises set the priority to good players and recruit players on the scene of competition. The players participating in the competition are outstanding students selected by schools. Therefore, they were welcomed by enterprises.

The teams which have outstanding performance and have won some prizes in competition can enter directly in the “competition talent pool”. This information platform could build a bridge between students and enterprises, and team members have priority to be recommended to the famous enterprises through the talent pool. In this way, the employment of students is promoted, and enterprises can select the best students.

3.7 Industrialization of outstanding works

Outstanding works in competitions can be further developed based on school-enterprise cooperation, and industrialization can be promoted. This is one of the important ways to build the industry of

university. By the industrialization of outstanding works, an effective combination of social funds and technology knowledge is established to promote the seamless connection of personnel training and the enterprise needs.

4. Competition case based on school-enterprise cooperation

In 21st century, facing the huge market demand of the intelligent equipment, such as communications, consumer electronics, industrial, medical, military and other industries, the global embedded industry got rapid development; whether it is mp3, video machines, mobile phones, PDAs, smart television, smart refrigerator, or industrial production, entertainment robots, defense systems, they all adopt embedded technology.

Due to the huge market demand, the talent demand of embedded industry is exuberant. Although the major multinational corporations and domestic appliance giants, such as INTEL, TI, SONY, Samsung, TCL, Lenovo, Haier and other enterprises, have great need to hire embedded talents, they still cannot find the right ones easily. What is ironically enough, university graduates cannot find a suitable job at the same time.

The cause of this situation is that the requirements for professional level of talent and the actual operating capacity requirements are higher. Without practical operations, or actual embedded works, students cannot grasp the embedded technology. Whether the finished product can be recognized by society is the key to select talent for companies. Therefore, enterprises need a platform to select the truly practical talent; students need a platform to practice and demonstrate their abilities; schools need a platform to verify whether the teaching system is perfect. “Up-tech Cup” National Undergraduate Embedded Design Contest came into being in this background!

Up-tech Cup National Undergraduate Embedded Design Contest has developed into the highest level annual event in the embedded field. Its operation model is: “organized by Chinese institute of electronics, undertaken by universities, supported by business, participated by students”. The sub-divisions are established in multiple areas of the country. The National Organizing Committee organizes the sub-divisions, and guides the selection of National Finals.

4.1 Build technology competition platforms through school-enterprise cooperation

University established joint laboratories with a number of domestic and foreign companies, and jointly set up the competition platforms. For exam-

ple, Intel Company, Beijing Up-tech Company, Huawei Technologies, ZTE, Redhat and other enterprises have established joint laboratories to jointly train hardware and software personnel. Students participate in product development in the joint laboratories. Therefore, they can meet the engineering requirements after their graduation.

In addition, university set up "IT application personnel training center" to provide the out-standing engineer which can adapt business at the shortest period of time. The important task of the training center is to make full use of spare time. Students actually learn the skills of docking with the future work. According to the needs of the market, university help students gain practical experience and become a quasi-professional staff.

IT training center build an application platform where students develop real projects, practice business plan and train for competitions. IT Training center open many training programs according to market demand, hiring highly professional teachers to give lessons. IT Training center regularly invite experienced project engineers, project managers to guide students, so that students will be able to participate in actual projects, obtaining a wealth of practical ability.

4.2 Open proposition around the industry/enterprise requirements

Competition uses the latest products sponsored by enterprises, and enterprises standard leads technology competition standard. For the emerging wireless sensor network and Internet of Things industry, according to the needs of enterprises, open proposition is adopted to allow teams to have more free space. The competition proposition covers: Internet of Things applications (urban transport, medical, port logistics, environmental monitoring, multi-network integration, etc.), consumer electronics, digital TV, GPS navigation, smart phones, digital home appliances, multimedia, video encoding and decoding, image processing, security monitoring, wireless communications, information identification, industrial applications, medical and health areas, application software, system software, and so on.

Around the needs of sponsors and industry, students can develop the following products: green lighting, green power, a variety of ultra-low-power handheld devices, intelligent robots, a variety of smart/RF card system, intelligent medical testing/analysis/health products (including household), smart energy-saving appliances, automotive electronics, industrial automation and control, smart meters, and other hot fields of application innovation. Students can design all kinds of intelligent devices, digital sensors, etc.

4.3 Enterprises participate in the evaluation of technology competition

In addition to university experts, we also invite some well-known experts and engineers from companies to participate in the evaluation of competition works, including the Up-tech technology, Nokia Qt Development Frameworks sector, NXP Semiconductor, U.S. Wind River Systems company, college planning ministry of Xilinx company, and so on. These companies provide the competition development platforms, devices and development environment. The business experts are so familiar with the system that the high level of competition and fairness are ensured.

4.4 Enterprise-oriented talent pool construction

Enterprises carry out recruitment on the scene of technology competition. During the competition, hundreds of enterprises representatives watch the game on the scene of technology competition, recruiting outstanding winners. Shown in Fig. 1, the teams selected by "Up-tech Cup" National Undergraduate Embedded Design Contest Finals can be input directly to the "Up-tech Cup talent pool", which build a bridge between students and enterprises. Team members can be recommended to well-known enterprises by the talent pool.

4.5 Industrialization of outstanding works

For outstanding works in competition, many companies showed great enthusiasm, and actively discussed the further development and industrialization. For example, the innovative work of "the remote analysis and scientific decision-making intelligent system of water quality in rivers and lakes" won the country's second prize, and then it won the "2010 scientific and technology project of social development in Shaanxi Province", as well as the "special research plans of education department in Shaanxi Province". A joint development agreement was signed with an enterprise to realize industrial-

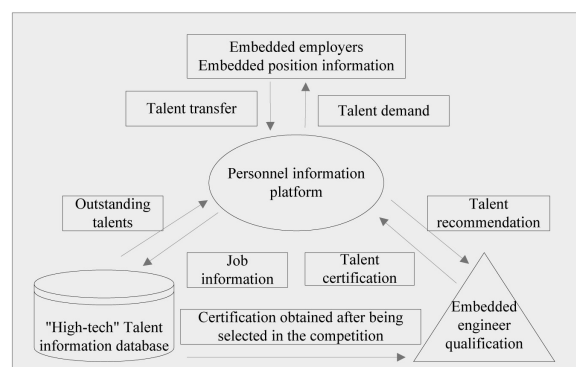


Fig. 1. The National Undergraduate Embedded Design Contest talents delivery process.

zation. After the work “modern agriculture adaptive irrigation systems” obtained the Grand Prize, a company signed an agreement with the team to inject funds about \$50,000 for deeper development and its industrialization.

Since the “Up-tech Cup” National Undergraduate Embedded Design Contest was held in 2005, this competition has been successfully held for eight years. Each time, many works had realized industrialization by auction, patent-pending, or deep development, which have obtained substantial economic interests and social benefits.

5. Effect analysis

National Undergraduate Embedded Design Contest always insists on the principles of fairness, justice, and openness. It is committed to building high-quality competition, and has obtained unanimous praise of cooperative enterprises and students. The competition is reported by a number of media, such as China Youth Daily, Guang Ming Daily, Sohu, Sina and others, and it has become the most influential domestic competition in the embedded field. The Competition plays a positive role in promoting embedded curriculum reform and curriculum practice. It improves the students’ sense of innovation, and teamwork, and also provides a reference for the selection of outstanding embedded technical personnel.

5.1 Entry range

Since the first “Up-tech Cup” competition was held in 2005, it has been successfully held for eight years. Nine sub-divisions were established in the country, so the influence of the competition has become increasingly wide. According to incomplete statistics, more than 1 million students had participated in the competition, and 30 percent of China colleges and universities participated in the “Up-tech Cup” competition. Many colleges have reported the situation of participating in the provincial and national “High-tech Cup” competition.

As shown in Fig. 2, more and more colleges and universities participate in the competition. In the “Up-tech Cup” competition, the number of schools participated has developed from the first 52 to more than 190, including many major colleges and universities. The seventh competition attracted 520 teams of more than 190 colleges and universities. Whether the “985 project” universities or “211 project”, or local colleges, are all involved in this competition.

As shown in Fig. 2, participating works became more and more. For example, 125 works run into the final in the 1st competition, while a total of 520 works run into the final in the 7th competition.

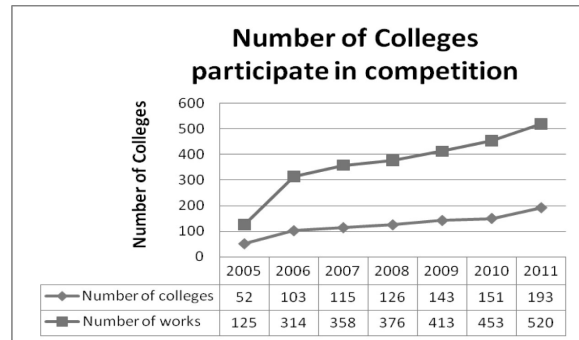


Fig. 2. The number of colleges and universities who participate in the competition and the works that reach the final.

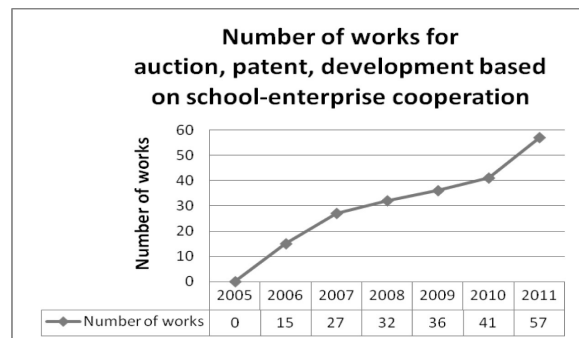


Fig. 3. The number of the auction of the works, patent-pending, deep developed by school-enterprise cooperation.

As shown in Fig. 3, from the number of works auction, patent-pending, deep development in the past seven years, the quality of the works has greatly improved, because only high-quality works can meet the needs of enterprises.

5.2 Enthusiasm analysis of students who participate in the competition

In practical teaching, many students still regard exam as the learning objectives, learning motivation is obviously insufficient. When students successfully resolve software or hardware questions of competition, they show unprecedented enthusiasm for learning. Therefore, it is necessary to introduce training methods and evaluation rules of competition to stimulate the interest of students.

Participating students generally reflect that they gain a lot in the competition. First, competition has greatly inspired the students’ interest and enthusiasm. Through competition, students have a deep understanding of embedded product development, and they learn a lot of things which they cannot learn at class. Second, students’ competitive consciousness is improved. In today’s society, competition is multifaceted, including technology competition, talent competition and so on. Students strengthened their competitive consciousness through the competition, which will become a useful attempt to adapt to the social competition

in the future. Third, students' team cooperation ability and communication skills are improved, which lays a good foundation for their future work. Modern enterprises generally attach great importance to team cooperation ability, because the internal division of labor is more and more systematic and professional, so they must rely on team cooperation in the fierce competition.

However, according to the visit to the participating students, some students have utilitarian psychology, that is, they take award or award level for their purposes. The utilitarianism weakened their pursuit of the scientific spirit. From the beginning of the competition, they only care about the competition results and rankings, while ignore their own thinking ability and exercise ability, resulting in the spread of the utilitarian. However, the authors believe it is no ground for blame, and utilitarian should be treated in a rational manner. We should admit that the utilitarian is a very effective power for student' learning, but it cannot be excessively pursued, and teachers should try to guide it.

5.3 Training effect analysis through technology competition

The effect of personnel training becomes more and more large. "Up-tech Cup" competition trained a group of technology professional, and some excellent young scholars and technology experts stand out from participants. Sixty percent of the winning students pursue higher level of education, and nearly thirty percent are gainfully employed by enterprises.

We invited 155 students majoring in Electronic Engineering and Computer Science Engineering to fill our training effect questionnaire in 2012 from aspects such as the improvement of engineering design ability, the training of team cooperation ability, and the promotion of job hunting. Almost all of the students like the school-enterprise cooperation model of competition very much. They believe that this model can help them deeply understand the development of society and industry, which is very useful for their future employment and work. As shown in Fig. 4, 121 of the students believed their engineering design ability were improved obviously, which accounted for 78.1%, 34 students believed their engineering design ability were improved, which accounted for 21.9%. 113 students believed that their team cooperation abilities were improved obviously, which accounted for 72.9%, 19 students believed that their team cooperation abilities were improved, which accounted for 12.3%. 129 students believed the competition is very useful to their job hunting, which accounted for 83.3%, 20 students believed the competition is useful to their job hunting, which accounted for 12.9%.

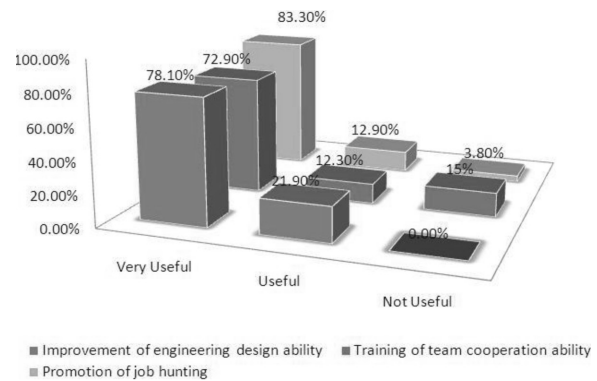


Fig. 4. Survey on the training effect questionnaire.

88.65% of the students believe that they can independently complete a project after this competition. Therefore, the competition has received wide approval from students.

The positive student feedback is a clear indication of the success of our model. Such intensive, systematic practices make the average level of these students much higher than other students, so they are very popular in the job search process. What is more, the practice strongly increases the leadership and communication collaboration abilities of students, so the development of these students in the enterprise is also very good. We keep in touch with a part of students, their feedbacks indicate that, many students are quickly familiar with the work of enterprise, and become technology backbone. Some students have gone into the management position in a short time.

5.4 Analysis of enterprise support

By sponsor and hosting the competition, enterprises' popularity is expanded, and their advanced technology and equipments get a promotion. Through on-site recruitment, many enterprises get outstanding talents. As shown in Figs 2 and 3, during the 6th "Up-tech Cup" Final in 2010, 41 works stand out from the 453 entries to participate in the public auction. They have received 14 national patents, and more than 20 works were undergoing national patent approval. During the 7th "Up-tech Cup" Final in 2011, there were 57 works signed contracts with enterprises, and the contracted amount exceeded \$500,000. Competition brings creative works to enterprises, so enterprises have obtained the huge interest through industrialization.

5.5 Analysis of college satisfaction

Technology competition effectively promotes the teaching reform of university, improves the teaching level of university, and cultivates students' creative ability. Technology competitions not only provide students with opportunities for deeper study and

practice, but also effectively promote students' employment.

Competition based on school-enterprise cooperation gives fresh impetus to the launching of "Out-standing Engineers education and training plan". Our university regards competition as an effective mean to promote innovation education, to build the organization system of science and technology innovation, and to establish the project development and transformation system based on the market demand. Our university has made outstanding achievements about competition based on school-enterprise cooperation, and has promoted personnel training model reform, therefore, in 2011, the China Ministry of Education selected our university as the pilot university of "Out-standing Engineers education and training plan".

6. Conclusion

Technology competition based on school-enterprise cooperation effectively promotes the reform of personnel training system and the implementation of "Out-standing Engineers education and training plan". We propose a model of technology competition based on school-enterprise cooperation, including: building the platforms of technology competition through school-enterprise cooperation; opening proposition around the industry/enterprise requirements; enterprises participating in the evaluation of technology competition; enterprise-oriented talent pool construction; industrialization of outstanding works. Through a case of "Up-tech Cup" National Undergraduate embedded design contest for many years, the application of the above model is elaborated. University and enterprises cooperate with each other, and benefit mutually, a virtuous circle has been gradually formed. Moreover, we analyzed the effect of technology competition based on school-enterprise cooperation from the entry range, students' attitude, enterprises' support, and colleges' satisfaction. But there is still a gap between our achievements and the overall goal of "Out-standing Engineers education and training plan". How to train future-oriented, innovative capacity, high-quality engineering talent? It still needs positive thinking and further efforts.

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