WHOLE PROCESS ENTERPRISE INTERNSHIP INVOLVING "SIX ELEMENTS" BASED ON CDIO

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ABSTRACT

Enterprise internship is not only an important method to implement CDIO engineering education, but also a complex engineering system involving multi-party interests and cooperation. Based on an in-depth study of the connotation of enterprise internship and the win-win points of all parties, using CDIO and the outcome-based education (OBE), this paper proposed an enterprise internship involving the "six elements" of orientation integrated design, target indexation, curriculum-based design, diversified implementation modes, effective evaluation and improvement, and institutional operation and management, which covers the whole process of talent cultivation from enrollment to graduation. To implement the proposed enterprise internship, a "six common" cooperation mechanism is constructed. Based on the enterprise internship involving "six elements", a four-year coherent curriculum combining enterprise internship and on-campus courses is developed, which contributes to the talent cultivation mode with engineering abilities training as the mainline. The curriculum has been applied on the Department of Automation at Beijing Institute of Petrochemical Technology (BIPT) and the outcomes from the curriculum are reported in this paper.

KEYWORDS

Enterprise Internship, CDIO, Outcome-Based Education, Curriculum Design, Cultivation Objectives, Continuous Improvement of Education

INTRODUCTION

Enterprise internship is an important method to implement CDIO Engineering Education. But there are some problems in the implementation process, such as illegibility of personal positioning and orientation, simple form, empty content, poor implementation effect, etc. The disconnection between internships and on-campus curriculum weakens the effects. Therefore, the key point and difficulty in the implementation of CDIO is how to break through traditional intern mode and innovate internship curriculum and teaching methods, and thus to build a practical internship curriculum which aims at developing students' practical engineering ability.

At home and abroad, a great deal of research and practice have been carried out on the construction of practical teaching system of engineering education. Wang, et al. (2017) analysed two paradigms of modern engineering education system in China. The Ministry of Education of China has put forward the requirement of " taking the construction of new engineering disciplines as a powerful hand to lead the reform of higher education" (Gu, 2017). In August 2017, MIT has launched a new round of engineering education reform, the "New Engineering Education Transformation" (NEET) program. Aiming to plan engineering education to return to the essence of engineering practice (Xiao & Qin, 2018).

German engineering higher education has effectively implemented the dual system for a long time, which organically integrate classroom theory and enterprise practice, aiming to organically integrate the dual identities of students and apprentices, and promote the collaboration of dual entities between universities and enterprises. Corporate internship is the most important part of the practical teaching system of the German University of Applied Sciences. It includes pre-entry internships and two internship semesters (arranged in the third and sixth semesters, respectively). The purpose and content of each internship are different, but the three of them constitute an organic whole. Enterprise internship and theoretical teaching are carried out parallel and gradually deepened, becoming an important measure to cultivate students' practical ability and the ability to solve engineering practical problems (Xu, 2017; Chen, 2015).

The main characteristics of French engineer education are multi-level practical training and a large number of practical courses (Wang & Jiang, 2014). Many courses are taught by experts or engineers from companies, and the teaching mode is divided into lecture and manual operation. During the study period, students must perform internships of varying duration in the enterprise. These internships are important parts of the teaching process. The internship mode is "three-stage internship", and it is strictly supervised in three parts: pre-internship related course preparation, internship approval and internship report defence. Enterprise Cognitive Internship: In the first academic year, the student worked as a worker will go to the enterprise for one month to gain basic knowledge of enterprise management and professional technology; Engineer Internship: In the fourth academic year, the students worked as a technician in the enterprise for half a year to contact and solve technical problems in actual industrial production; In-depth internship and engineer graduation internship: In the fifth academic year, the student went to the enterprise for half a year as an engineer, independently thinking about engineering problems and solving industrial production and engineering problems of a certain degree of difficulty, and writing graduation internship report around the technical problems in actual industrial projects that were solved.

Wan, et al. (2019) proposed a new paradigm of talent cultivation that runs through the entire process of training objectives, training modes, curriculum systems, teaching modes, teaching content, and training quality standards. Cultivate engineering practice ability through the school-enterprise collaborative education practice platform, and build a second classroom education system. Dong, et al. (2019) takes CDIO as the educational concept, divides the teaching content of production practice according to a certain level, and proposes a production practice mode in which universities and enterprises cooperate, and actual operation and simulation practice support each other. Sun, et al. (2013) built a multi-level internship teaching system for chemical engineering and technology speciality practice teaching per the CDIO mode, including chemical knowledge practice, chemical practice training, chemical production practice, and chemical graduation practice. Based on the CDIO engineering education concept, Jiang, et al. (2018) explored a new practical teaching mode centred on the construction of corporate practical teaching bases, reforms in the evaluation of practical teaching results, and feedback on the quality of practical teaching.

Enterprise internship is a complex engineering system involving multi-party interests and cooperation. This paper investigates the connotation of enterprise internship and the win-win points of all parties. Based on CDIO and the outcome-based education (OBE), this paper proposes the “six elements” of orientation, goal, design, implementation, evaluation, operation for a whole project life circle and then combines all these “six elements” with the whole process talent cultivation mode of Department of Automation at Beijing Institute of Petrochemical Technology (BIPT). Finally, a whole process enterprise internship involving the “six elements” is constructed and a four-year coherent curriculum combining internship and on-campus courses is developed.

CONSTRUCTION OF A WHOLE PROCESS OUTCOME BASED ENTERPRISE INTERNSHIP INVOLVING THE “SIX ELEMENTS” OF ORIENTATION, GOAL, DESIGN, IMPLEMENTATION, EVALUATION AND OPERATION

We positioned the enterprise internship as the enterprise stage learning of school-enterprise cooperative education, which includes: enterprise visit, cognition practice, school-enterprise cooperative engineering practical courses, production practice, post-practice, graduation practise, etc., covering the whole process of talent cultivation from entrance education to graduation design and employment. The methods of practice include: centralization at the base, scattered in enterprises, tourism-class-hands-on mixture, mentoring, in-post, engineering case design, site visit, enterprise engineer lecturing, enterprise team leader lecturing, etc. All these practices have clear goals. Taking these practices as teaching stages, each stage has its objectives which can be given clear indicators, so the effect of practice can be evaluated. A two-level matrix (Dai, et al. 2017) is used to reverse design the enterprise practical course system and a complete outline of is made for each of the practical courses. Thus, a systematic solution to the problem of difficult enterprise practice is implemented.

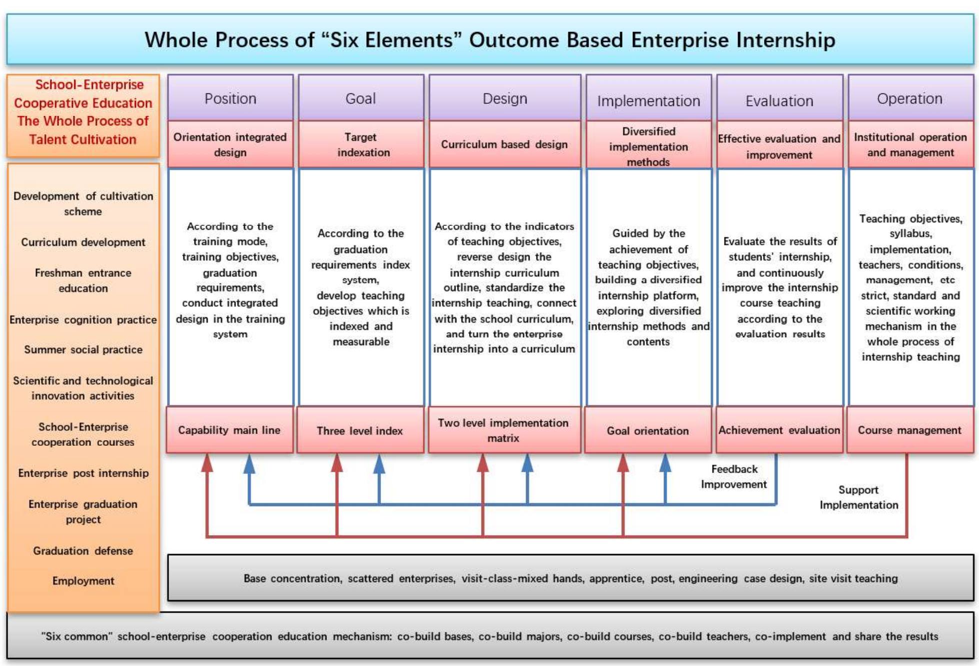

Figure 1. Whole process outcome-based enterprise internship involving the “six elements”

Whole Process: As the enterprise-stage learning of school-enterprise cooperative education, varying from cognition practice to graduation internship, enterprise internship covers the whole process of talent cultivation from entrance education to graduation project and employment, and is taken as one stage of collaborative education.

Orientation Integrated Design: Aiming at the cultivation of the ability to solve complex engineering problems, the internship and on-campus courses are integrated into the curriculum design to achieve the graduation requirements.

Target Indexation: To formulate clear, indexed and measurable enterprise internship objectives, a three-level index system of graduation requirements, index points and teaching objectives are established, which further determines the internship objectives.

Curriculum-based Design: According to the internship objectives indicators, the two-level realization matrix is used to reversely design the internship curriculum, including standardizing the internship teaching, and making the internship consistent with on-campus courses.

Diversified Implementation Modes: Oriented at the achievement of enterprise internship, diversified internship platforms, methods and contents are constructed.

Effective Evaluation and Improvement: Evaluation of internship effects is carried out according to the internship objectives. The orientation, goal, design and implementation of the internship course are continuously improved according to the evaluation results. Thus, the internship effect is eventually guaranteed.

Institutional Operation and Management: Enterprise internship is included in real curriculum management. The whole process of internship is strictly regulated, including objectives, syllabus, implementation, teaching group, environments, operation management, etc.

Outcome-Based: Reversely design the internship course system based on the teaching objectives and then improve the internship based on the evaluation of the achievement of the goal, that is, the internship effect.

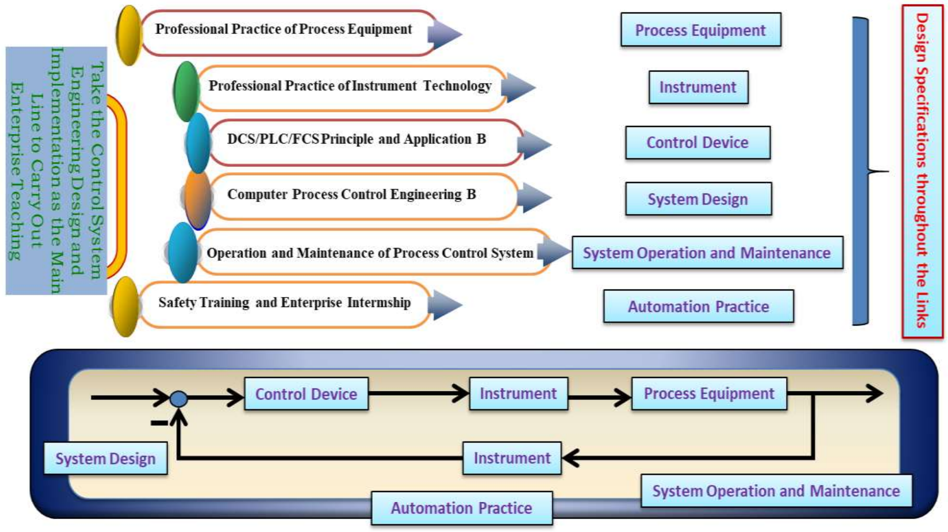

Figure 2. Designing the enterprise internship in the Department of Automation with control system design and implementation as the mainline

Taking Department of Automation in BIPT as an example, we decompose the graduation requirements based on the CDIO syllabus into three-level index system: graduation standard, index point and course teaching goal. The implementation of control system engineering design is the goal of enterprise internship teaching. The four-year coherent curriculum combining internship and on-campus courses is developed, which comprehensively promotes the establishment of professional training objectives, the formulation of graduation requirements index system, the integration of curriculum system, the reform of learning and teaching, and the construction of teaching staff. The talent cultivation mode with engineering abilities including design, practice and innovation as the mainline is constructed and implemented.

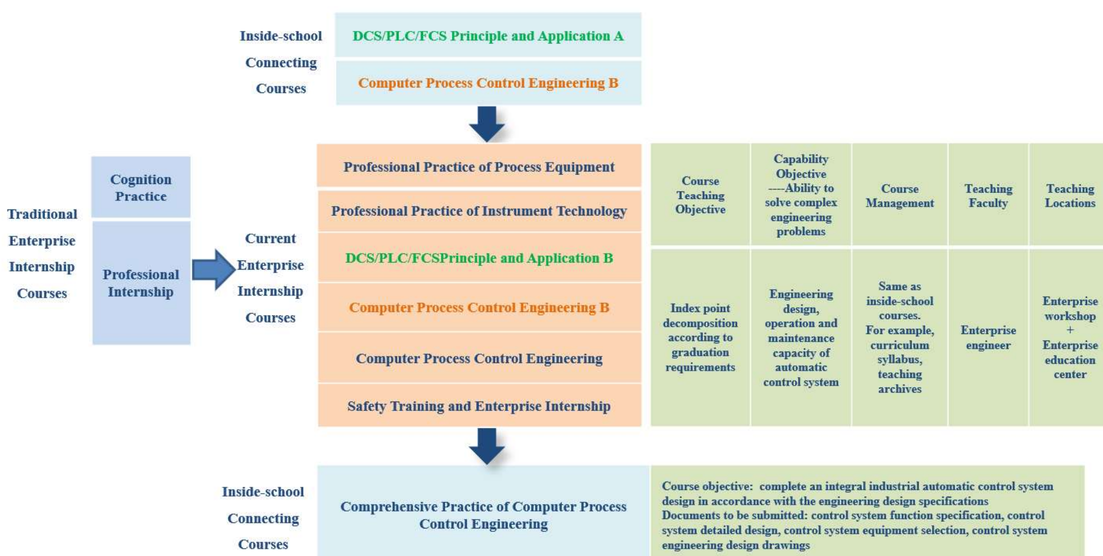

Figure 3. Inside- and outside- school integrated school-enterprise cooperation engineering practical courses for Department of Automation

CONSTRUCTION OF THE "SIX COMMON" COOPERATION MECHANISM

It requires an in-depth cooperation between college and enterprise to implement the whole process enterprise internship involving "six elements". But due to the unclear orientation, vague objective, void content and poor implementation effect, there seems to be no win-win point for enterprise internship. Therefore, insufficient internship funds are invested by our college and the enterprises also take little interest in the cooperation. To solve the difficulty in enterprise internship arrangement, a thorough investigation was made by industry representatives, teachers and leaders of our college. It is found that what college needs are the engineering environment, engineering cases and teachers with engineering background. The investment of college is education funds, an open and organized education market, teachers with research backgrounds and their research achievements. On the other hand, what the enterprises have offered are engineering environment for talent training, engineering cases and teachers with engineering background. The demand of the enterprises is human resources, talent resources, education market, capital and benefits of scientific and technological achievements. Moreover, it is found that the school demand and the enterprise match well, but the school investment and the enterprise demand match badly. Thus the win-win points which we are looking for are the talents, capital gains and scientific research achievements that can meet the demand of enterprises. Therefore, more funds are invested, the talent demand of enterprises are tracked, and cooperation mechanism that can improve the matching degree are innovated. Thus the "six common" school-enterprise win-win cooperation mechanism which includes co-construction of base, department, curriculum, teachers, joint implementation and shared outcomes is proposed. After years of implementation, the "College-Enterprise", "College-Industrial Park", "College-Research institutes", "College-Industry Association", " College-Government" and other diversified internship platforms, modes and mechanism have been established as shown in Figure 4. The construction of a national engineering education centre and several practical teaching bases has effectively guaranteed the implementation of outcome-based enterprise internships.

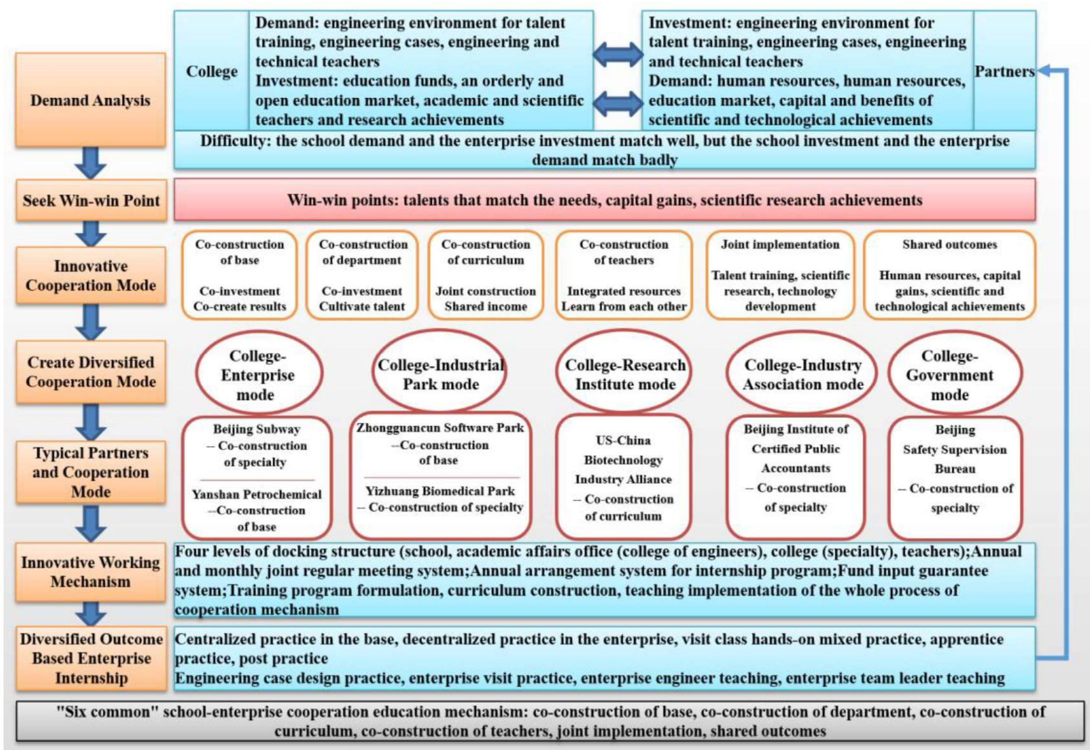

Figure 4. The "six common" school-enterprise win-win cooperation mechanism

School-Industrial Park Co-Construction Base: The cooperation between Department of Pharmaceutical Engineering and Beijing Yizhuang Biomedical Park has been implemented since 2012. In September 2013, College of Chemical Engineering and Beijing Yizhuang Biomedical Park decided to establish a "biomedical park class" after negotiation. Both parties agree that (1) The professional curriculum setting, syllabus, assessment method, and teaching implementation of the class are determined and led by the medical park. The teaching and practical teaching of the course is all undertaken by the selected teachers in the medical park. The teachers in the school only assist Manage curriculum standardization; (2) after the completion of the medical class, the students of the class shall be selected by the park enterprise for one year of enterprise training in the park enterprise; (3) when they graduate, they will make two-way selections according to both the needs of the enterprise and the individual wishes. At present, three students of the medical garden class have graduated, and one student of the medical garden class is about to graduate. Thanks to the joint efforts of both parties for several years, Yizhuang Biomedical Park became the “Beijing Municipal Off-School Talent Cultivation Base” in 2015.

School-Enterprise Co-Construction Department: BIPT has established a long-term cooperative relationship with Beijing Metro Operation Co., Ltd. Their branch office of communication signal and Department of Communication Engineering jointly build the professional field of Subway Communication and Signal. Their branch office of power supply and Department of Automation jointly build the professional field of Subway Power Supply. Every year, professional trainings are provided for students in four professional fields: subway line communication, signal, automatic ticket sales (AFC), and power supply. After taking the late-stage customized subway courses, some students go directly to the subway company to accomplish their graduation project and get employed.

School-Industrial Park Co-construction Courses: In 2012, BIPT and Zhongguancun Software Park successfully co-established the “National Engineering Practical Education Centre” and “Beijing-level Off-campus Talent Cultivation Base”. The “group-to-group” cooperation mode adopted has changed the conventional school-enterprise cooperation education mode of “point-to-point” or “point-to-face” implemented in the past, which has brought the superiorities of our College of Information Engineering into full play. Moreover, this co-construction has a good reference for BIPT to concentrate their efforts to build a high-level engineering application discipline group and improve efficiency in teaching management. Now, Zhongguancun Software Park not only provides engineering practice education for majors of Information Engineering and Mathematics in our college, but also provides open student training services for other universities.

CONSTRUCTION OF THE TALENT CULTIVATION MODE WITH TRAINING OF ENGINEERING ABILITIES INCLUDING ENGINEERING PRACTICE, DESIGN, AND INNOVATION AS THE MAINLINE

An in-depth cooperation is both the most important mode for high-level cultivation of applied engineering talents and the most difficult and weakest step. The whole process enterprise internship involving "six elements" solves this problem. The "six common school-enterprise win-win cooperation mechanism ensures the implementation. Thus the school curriculum and enterprise practice, theory teaching and practice teaching, general education and professional education, basic courses and specialized courses are integrated. Moreover, with the orientation of training target and graduation requirements, engineering ability training as the mainline, a two-level realization matrix is adopted to implement the integrated curriculum system design, which further pushes forward a systematic and comprehensive implementation of talent cultivation mode focusing on the training of engineering innovation ability (Dai, 2017). The new model has not only promoted the formulation of training objectives and graduation requirements index system, promoted the integration of curriculum system and curriculum outline revision, but also strengthened the connection between school courses and enterprise practical courses. Moreover, it promoted the construction of the teaching staff. Focusing on the cultivation of engineering practice ability and innovation and entrepreneurship education, the training mode with engineering practice, engineering design and engineering innovation ability as the mainline has been respectively constructed and implemented in different departments. This has led to the education and teaching reform of the whole school through experimental departments of excellence.

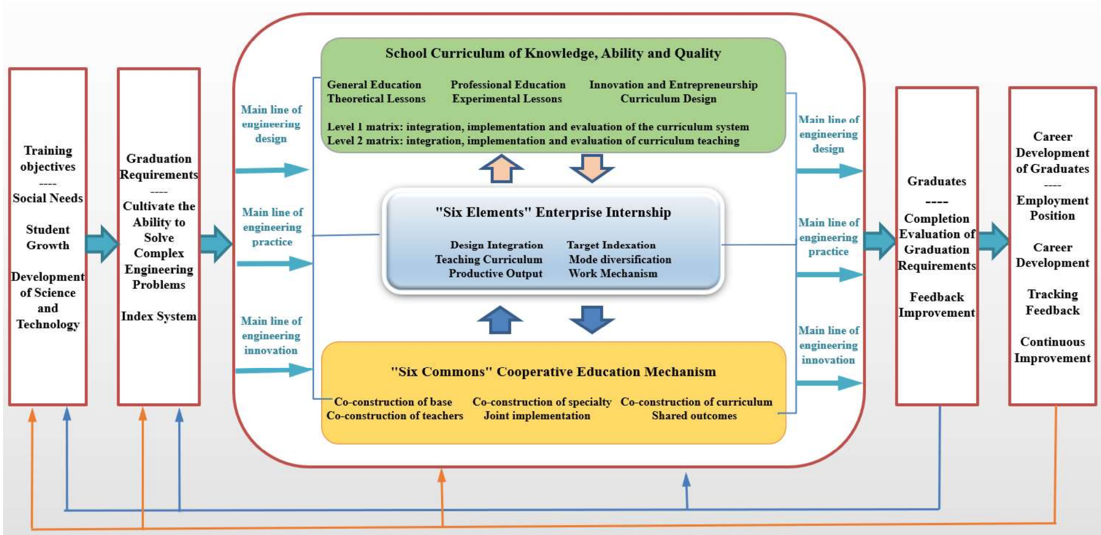

Figure 5. The talent cultivation mode with abilities training as the mainline

Construction and Implementation of a Talent Cultivation Mode Focusing on Engineering Training of Practice Ability

The automation major has implemented an application-based automation system of "one competence mainline, two-level realization matrix, and three-stage cooperative education" to prepare engineers for talent cultivation. With the goal of competence development, it has comprehensively integrated and restructured the curriculum system, formulated curriculum outlines and teaching implementation plan, students are trained around the system design, product integration, engineering installation, system commissioning, device commissioning and maintenance of an actual production device or actual engineering project to complete the process of training for the entire life cycle of an engineering product.

The major of mechanical engineering, to strengthen the cultivation of engineering application ability, combine knowledge learning, ability training and engineering practice to form a "one mainline + two pillars + three modules + four cornerstones" of the entire process of engineering application ability training as the mainline of talent cultivation mode, construct a learning system that combines the "engineering quality, engineering foundation, engineering technology" knowledge transfer system with the "engineering quality training, engineering technology training, and enterprise engineering practice" ability training system.

Construction and Implementation of Talent Cultivation Mode Focusing on the Training of Engineering Design Ability

Chemical engineering and technology major, the four-year practical teaching and theoretical teaching of the university with engineering design ability training as the mainline to build a talent training program, in the four "designs" of basic design, professional design, factory design, product and process design and research, three internships including preliminary internship, vocational internship, and professional internship are interspersed.

Construction and Implementation of Talent Cultivation Mode Focusing on Training of Engineering Innovation Ability

Taking students to participate in discipline competitions, scientific research practices, and innovation activities as carriers, relying on internal and external practice bases to build platforms for innovation and entrepreneurship projects, optimize talent cultivation modes, and integrate innovation and entrepreneurship education throughout the entire process of talent training, and build a perfect innovation and entrepreneurship education system, and formed a new mechanism of collaborative education involving schools, local governments, enterprises and institutions. Students' innovation and entrepreneurship ability has been greatly improved, and innovation and entrepreneurship achievements are gratifying.

Since 2013, a total of more than 3,200 students from 817 project groups have received support from various types of "University Innovation and Entrepreneurship Training Programs" at various levels. Each year, more than 130 students participate in the program, about 4000 students take part in it, with a large number of students participating in it and benefiting from it, forming a good echelon structure. Organized the school selection and training activities of chemical engineering design competitions, mechanical innovation competitions, electronic design competitions, mathematical modelling competitions and other discipline competitions, to achieve the full coverage of relevant professional students. Since 2011, our university has won a total of 1,015 science and technology competition awards at or above the provincial level, including 416 national awards and 599 provincial awards. In 2016, our school students won the first prize in Beijing second and the 4 prize in the three prizes of the first prize in the "Internet +" College Student innovation and entrepreneurship competition in China. The project "pipeline inspection robot" was the only one of the Beijing municipal colleges and universities to enter the national competition and win the bronze medal of the national finals. In 2014 and 2015, the practice base of comprehensive innovation education for college students and the practice base of comprehensive innovation education for mechanical engineering were successively awarded the "Beijing University demonstration innovation practice base in school". In 2017, the employment and entrepreneurship guidance centre of our university was awarded the "Beijing demonstration entrepreneurship centre", and our University has become the "Beijing demonstration University of deepening innovation and entrepreneurship education reform".

CONCLUSION

Mode innovation: Take enterprise internship as a breakthrough, and systematically implement a talent training mode focusing on engineering ability training

Difficulties in implementing the "Excellence Plan" were solved. The constructions of graduation requirement index system, curriculum system and teaching groups were promoted. Each department has established corresponding cultivation mode with engineering abilities of practice, design and innovation as the mainline.

Program innovation: The "six elements" outcome-based enterprise internship program was proposed and implemented systematically

Based on the investigation of the connotation and elements of outcome-based enterprise internship, we broke through the traditional internship model, designed a novel internship curriculum system, and constructs an outcome-based enterprise internship of "orientation integrated design, target indexation, curriculum-based design, diversified implementation modes, effective evaluation and improvement, and institutional operation and management ". Thus, system solutions have been proposed and implemented for the difficulties of internship.

Mechanism innovation: Explore and practice the "six commons" school-enterprise cooperation and win-win cooperation mechanism

Based on multi-party collaboration, increasing investment, and in-depth cooperation, several win-win modes have been found. In terms of the whole internship process and all elements of teaching, bases, departments, courses, teaching groups have been co-constructed and all the achievements are shared between our college and the enterprise. The "College-Enterprise", " College-Industrial Park", "College-Research institutes", "College-Industry Association", " College-Government" and other diversified internship platforms, modes and mechanism have been studied.

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BIOGRAPHICAL INFORMATION

Bo Dai is a Professor of Automatic Control at the Department of Automation and Director of Academic Affairs Office at Beijing Institute of Petrochemical Technology, China. He taught the course of automatic control theory. His current research focuses on industrial process control and curriculum development methodology. He took the lead in constructing the applied talents training mode with ability training as the mainline and won the first prize of Beijing Higher Education Teaching Achievement Award. The mode has been widely implemented at Beijing Institute of Petrochemical Technology.

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