

Exploration of the Innovative Multi-dimensional Talents Training for Mechanical Engineering Specialty in China

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Abstract: In view of the current engineering personnel, innovative personnel training mode and teaching system was difficult to adapt to the new needs of the industry. This paper put forward multi-dimensional co-driven innovative personnel training concept based on the goal oriented education, school-enterprise cooperation education, science and education integration education, and competition platform education. Three-level progressive curriculum project system, three-level and five-link university-enterprise complementary joint training model, and a four-level extracurricular science and technology innovation platform were established. A capability achievement evaluation standard was also established based on concepts of process-based, output-oriented, quantifiable, controllable and multi-channel feedback. A research capability model of transforming engineering problems into scientific problems was built with the help of high-end teams and provincial and ministerial platforms. The deep integration of society, school and innovation team was promoted by construction of achievement transformation mode, with market demand as the leading role and practice incubation as the carrier. With the precise drive of team, project, platform, innovation and entrepreneurship, the training mode of application-oriented innovative talents has been established, which integrates theory and practice with the five-step promotion of teaching, production, competition, research and application. The teaching reform was carried out in Qingdao university of technology and collection data comes from student of mechanical engineering major in the past three years. The achievements of teaching reform was discussed from five aspects including 'teaching', 'production', 'competition', 'research' and 'application'. The analysis shows that the reform has achieved remarkable results.

Key words: Mechanical Engineering, Multidimensional culture, Goal-driven, Process control.

INTRODUCTION

The personnel training of mechanical engineering major focuses on the combination of theory and practice. The traditional teaching mode usually adopts the way of classroom teaching, experimental course and practical training. Therefore, the traditional teaching method of mechanical engineering discipline is characterized by unitary and less systematic, which leads to the disconnection between theory teaching and practice training. In this method, teachers or students must have strong ability to ensure the quality of teaching. Especially for undergraduate, the traditional teaching mode couldn't meet the constantly improving needs of the mechanical

industry (Hou *et al.*, 2017). Therefore, it is necessary to reform the traditional teaching mode and improve the teaching quality from the aspect of teaching system.

'Mass entrepreneurship and innovation' is China's national development strategy, which put forward higher requirements for the teaching and personnel training of mechanical specialty. It is of great practical significance to establish a three-dimensional training mode based on innovation and entrepreneurship education, application-oriented personnel training, collaborative education and comprehensive reform (Yang *et al.*, 2016a). In the current transformation period of economic supply-side reform,

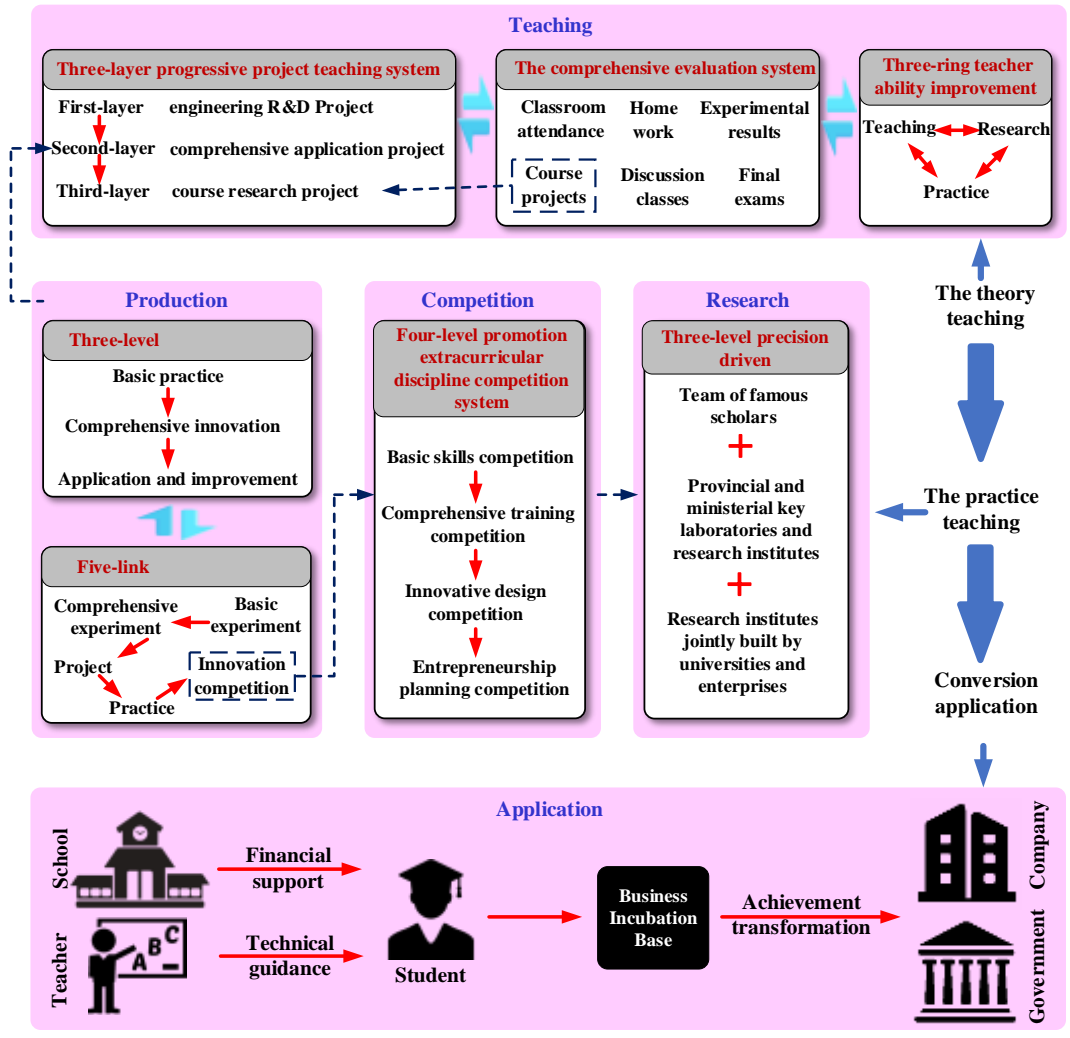


Figure. 1. The new model of multi-dimensional innovative talent training

the integration of ‘innovation and entrepreneurship education’ and ‘professional education’ is particularly important, which has become an important method for applied talents training in mechanical majors (Yang *et al.*, 2016b).

Based on this challenge, this paper aims to establish innovative talent training mode and carry out in-depth reform of teaching mode to improve teaching quality. This work was carried out at Qingdao University of Technology, which have national talent training base and internship practice base. It's worth noting that this work conforms to the professional certification requirement of the ‘Washington Agreement’ and based on concept of OBE (Outcome-based education) (Hu and Wang, 2017). We have established a three-level progressive curriculum project system, a three-ring complementary teacher ability improvement system, a three-level and five-link school-enterprise joint training mechanism, and a four-level extracurricular discipline competition system. The new teaching system achieve the comprehensive ability

cultivation including professional theoretical knowledge learning, engineering practice ability and scientific research ability. Further, Teachers will teach students turning engineering problems into scientific problems and turning research output into applications.

THE NEW MODEL OF MULTI-DIMENSIONAL INNOVATIVE TALENT TRAINING

The new model of multi-dimensional innovative talent training is showed in Figure. 1.

‘Teaching’: new teaching system

(1) Three-layer progressive project teaching system combines teaching, scientific research and production. The three-layer progressive project teaching system aims at improving students’ comprehensive engineering literacy and innovation and entrepreneurial ability. The establishment of the new system is divided into the

following steps.

i) The graduation requirements of engineering student were analyzed comprehensively and divided into several training objectives. Then, the ability matrix for the integration of theoretical knowledge learning and comprehensive accomplishment was elaborately designed. Further, we set the 'ability cultivation' as the core of teaching reform and make 'knowledge class' to 'ability class'. Based on this, the teaching content and course system, teaching method and means, experiment class, curriculum design and teaching evaluation were all changed and improved. Different from the traditional classroom teaching method, Knowledge is imparted to students in three ways including 'explanation of the theory' (to enhance teaching and learning ability), 'team-based experiential seminar' (to enhance scientific research ability) and 'project teaching' (to enhance practical application ability).

ii) In order to meet the requirements of engineering education ability, it should be emphasized that the implementation of new system should be followed in implement at 'problem-based learning', 'project-based learning' and 'case-based learning'. Teacher should make the subject and project throughout the whole teaching process and use various forms and ways to expand students' knowledge and engineering experience. Through effective communication and activity organization, improve the expression ability, team spirit, actively innovative thinking ability, engineering practice ability, engineering design ability and engineering innovation ability of student.

iii) The key part is the application of project teaching method. In this paper, three-layer progressive project teaching system includes course research project (third-layer, set up in a course), comprehensive application project (second-layer, set up based on a number of courses) and engineering R&D Project (first-layer, graduation project or innovative design project). In the process of project-based teaching method, five stages are as follow: ① determination of project tasks, ② formulation of work plan, ③ organization of project implementation, ④ inspection, assessment and evaluation, ⑤ summary, evaluation and archiving.

Among all kinds of teaching methods adopted by famous universities in the world, the most suitable one for engineering education should be the research learning method based on subject and project, which can be called research teaching method for teachers, also known as project-based teaching method (Yang *et al.*, 2016c). It is a teaching organization form and teaching method that conforms to the law of cultivating engineering ability and the logic of forming comprehensive quality (Li *et al.*, 2017). It has been widely applied in western countries, especially Germany, and achieved remarkable results (Yang *et al.*, 2016d). Project-

based teaching method is a practical teaching activity carried out by completing a complete 'project' work, assigning knowledge and skills involved in several courses to students through a clear 'project task'.

The innovative Integration of 'first class' and 'second class'

In general, the 'first class' is the main position of learning theoretical knowledge, which could be named as 'theory class'. The 'second class' is the main position of learning practice ability, which could also be named as 'practice class'. 'First class' and 'second class' are essential links, but which two are set as independent part in traditional teaching mode. In new system, the innovative Integration of 'first class' and 'second class' is the most important task. On one hand, teacher pay attention to make 'first class' as the theoretical basis for the smooth implementation of 'second class', in which specific purpose, thinking depth and feasibility could be gave for activities of 'second class'. On the other hand, new method takes advantage of the flexibility in time and space of the second class, and expands more channels for student to comprehensively understanding and applicate theory knowledge on production practice. Furthermore, the 'second class' provides possibility for the realization of 'engineering situation' and 'inquiry' teaching methods in the 'first class'. At last, in order to realize the overall teaching goal of mechanics training innovative and applied talents, the activities arrangement of the 'second class' should focus on the knowledge, practicality and innovation.

The comprehensive evaluation system based on output-oriented

To improve students' comprehensive engineering literacy and innovation and entrepreneurship ability, the evaluation standards of course were set in detail based on graduation requirements and ability refinement indicators. A process-based hierarchical teaching evaluation standard that comprehensively evaluates students' knowledge, ability and quality was established. And an output-oriented, quantified, controllable and multi-channel feedback accurate evaluation system for ability achievement was formed. In particular, classroom attendance, homework, experimental results, discussion classes, course projects, in-class tests, final exams and other aspects are set as assessment indicators in the classroom. In engineering projects and graduation practice, market analysis and forecast, cost analysis and life cycle analysis are innovatively increased as project content. Further, the self-assessment and mutual-assessment were adopted at the same time, which introduces competition mode in course projects.

Three-ring complementary teacher ability improvement system of 'teaching, research and practice'

Higher standards have been set for students' under the background of 'professional certification' and 'new engineering'. Meanwhile, higher requirements of knowledge, comprehensive ability and accomplishment have been set for teacher. Therefore, the key to achieve the training goal is to build a high level of teachers.

Relying on the Shandong Provincial Mechanical Engineering Training Center, Shandong Provincial Teaching Experiment Demonstration Center and cooperative enterprises, three-ring complementary teacher ability improvement system was established. The teaching, research and practice are combined to effectively improve teachers' teaching level, scientific research ability and practical ability.

Further, the concept of 'full cycle of teacher's practical competence' was put forward, which emphasizes that the training of teachers should be long-term and comprehensive. Focusing on the 'requirements of excellence plan for teacher's practical competence', the guiding ideology of 'promoting motivation with sense of mission education, promoting implementation with fine management, and ensuring quality with process assessment' was proposed and implemented. Based on this, the 'Teacher Practical Ability Improvement Plan' and 'Teacher Workstation' mode can help to exercise teachers' practical ability and give full play to teachers' theoretical advantages, so as to achieve a win-win situation between the school and the enterprise.

'Production': three-level and five-link training system based on university-enterprise cooperation

The comprehensive practical ability and innovative spirit of college students cannot be achieved only by classroom teaching and theoretical teaching, but also through the training of practical teaching. The role of practical teaching in this aspect is impossible to be realized by theoretical teaching, which is the key significance of practical teaching.

Guided by the big engineering and practice concept, the practical teaching system was established based on co-education between schools and enterprises. The new system contains three levels at the aspect of teaching content, including basic practice (first level), comprehensive innovation (second level), application and improvement (third level). The new system contains five links at the aspect of teaching form, including basic experiment, comprehensive experiment, project, practice and innovation competition. Therefore, it's a practical teaching system with a variety of forms and distinct hierarchy.

It's worth noting that we use as many of the school's

resources as possible to achieve a quasi-industrial and practical training mode within the school. The scientific research projects of teachers, the national innovation and entrepreneurship training program of student, provincial training center and experimental demonstration center are basis of implementation. In addition, the used of off-campus internships, off-campus graduation projects and engineering projects is also important practical training method, which make student solve problems and improve capacity at production site.

'Competition': four-level promotion extracurricular discipline competition system

A four levels promotion extracurricular discipline competition system contains 'basic skills competition', 'comprehensive training competition', 'innovative design competition' and 'entrepreneurship planning competition'. It works for students covering different grades and different majors. In this system, students and their team are encouraged to participate in extracurricular academic competitions at several levels including college, university, provincial and national. Through competition, the innovation and entrepreneurship ability, team cooperation ability, research and exploration spirit will be improved. And this system also cultivates students' ability to solve practical problems with comprehensive application of engineering knowledge and creative thinking.

'Research': three-level precision driven innovation mechanism between scientific research and talent cultivation

A university-enterprise joint training mode and mechanism was established with help from three aspects including 'Team of famous scholars', 'provincial and ministerial key laboratories and research institutes' and 'research institutes jointly built by universities and enterprises'. In this mode, university education and industry dynamics are closely linked. The communication and cooperation between university and enterprise characterized by bidirectional flow of information, interactive win-win results and each taking its own responsibilities.

In order to make the enterprise really joined in the whole process of university personnel training and guarantee the 'suitability' of talent training quality, enterprise personnel participated in several teaching sessions. Such as revision of the talent training scheme, professional construction, curriculum design, teaching outline design, compilation of textbook, teaching content optimization, engineering practice arrangement, teaching evaluation, engineering professional certification and new engineering construction, etc.

'Application': the achievement transformation mode of the deep integration of society, university and innovation team

The 'Business Incubation Base' is an important platform for the organic combination of production, education and research in universities. In this paper, The Business Incubation Base of Qingdao University of Technology gathers the strength of the local government, universities and enterprises. This university has set up a business incubation base of 14,045 square meters, which has cultivated 206 scientific and technological entrepreneurial teams and incubated 130 standardized entrepreneurial enterprises in the past two years. It has set up 10 innovation and entrepreneurship functional zones and an innovation and entrepreneurship mentor pool composed of 66 university experts and famous teachers and 163 off-campus famous scientists, successful entrepreneurs, entrepreneurs and other outstanding talents to provide entrepreneurs with continuous guidance services in technology, psychology, management and other aspects.

The Management Committee of Business Incubation Base also be established to guarantee the normal operation of the research team. The three-level management system contains university, the college, student community and the operation service mechanism of 'import-manage-help-outflow' were also built up. At the same time, Qingdao Technology Entrepreneurship Service Co., Ltd was established to hold shares of intellectual property and intangible assets on behalf of the university, which has stepped out of the new model of building entrepreneurial incubation bases in colleges and universities.

ACHIEVEMENTS OF TEACHING REFORM

The teaching reform was carried out in mechanical engineering major of Qingdao University of technology. In the past three years, the achievements are showed as follows.

- i) From 'teaching' aspect, the quality of training students has been improved comprehensively, and the employment rate of graduates has been increasing year by year. In recent three years, the total employment rate of graduates has reached 97%, and the admission rate of postgraduate entrance examination has been kept above 25%.
- ii) From 'production' aspect, more than 500 projects have participate in the national college students' innovative training program. Among them, 57 projects won the national competition award including 'the challenge cup national university student extracurricular academic science and technology work competition' and 'the national college students' mechanical innovation design competition'. More than 300 projects won the provincial science and technology competition award.
- iii) From 'competition' aspect, more than 300 research

teams were built up by student, who have obtained more than 300 Chinese national invention patents. The scientific and technological innovation project 'Taking Walnut Kernels skillfully' was reported on 'I Love the Invention' of CCTV-10. In addition, other projects were reported by China education news network, the public daily, China youth network, China science and technology network, Chongqing TV, phoenix network, Huayu education network, Qilu evening news and others.

iv) From 'research' aspect, at present, the innovative products have been jointly produced by Xinjiang Jiangning Light Industry Machinery Technology Co., Ltd., creating significant economic and social benefits. The research results have been made keynote reports in the joint meeting of the presidents of the National Mechanical Engineering College and the contact meeting of the Mechanical Engineering College of Shandong Universities, and the experience exchange in more than ten universities across the country.

v) From 'application' aspect, the new achievement transformation mode was visited and investigated by the main leaders of the government department heads and more than 300 universities and enterprises. It is widely believed that this system has outstanding characteristics of innovation and entrepreneurship, and has stepped out of the new mode of building entrepreneurial incubation base for colleges and universities. The typical practices and successful experiences of this work have been reported by CCTV, China Education Daily, Science and Technology Daily and other medias for more than a hundred times. Work experience has been shared by keynote speech on the national and provincial innovation and entrepreneurship work conferences for many times. The Business Incubation Base of Qingdao University of Technology has won the honorary titles of the 50 universities with typical experience in innovation and entrepreneurship in China and the first batch of national demonstration universities for deepening innovation and entrepreneurship education reform.

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