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Research Article

Training Mode of Innovative Talents in Higher Engineering Education in China*

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Abstract

The development of new economy and the coming of a new round of technological and industrial revolution put forward new requirements for higher engineering education. Innovative talents training has become an important part of higher engineering education reform. According to the analysis of the present situation and main problems of the training of innovative talents in higher engineering education in China, the "five-in-one" training mode of application-oriented innovative talents was established based on the systematic theories. In-depth exploration to the internal factors of such five subsystems as classroom teaching, practical teaching, discipline competition, second classroom and school-enterprise cooperation and to the coordinated operation mechanism between systems has been carried out. Specific measures for training innovative talents in engineering education are put forward, which has a strong practical guiding significance for the cultivation of innovative talents, and further motivates China to shift from a big country of engineering education to a powerful country in engineering education.

Keywords

Early Childhood Engineering Education • Innovative Talents • Training Mode • Five-in-one

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In China's higher education, engineering education occupies an important position, and the scale of engineering colleges, engineering specialties and engineering students is gradually expanding. In 2016, there were 5.21 million undergraduate engineering students, 1.19 million graduates and 17,037 offerings of the engineering specialties in universities. The number of students in engineering majors accounts for about 1/3 of the total number of students in higher education, so China has the largest engineering education in the world. In the new era, the supply and demand relationship, national demand, international competition environment and resource environment relating to Chinese higher education have undergone great changes. In particular, the development of new economy and the coming of a new round of technology and industrial revolution put forward new requirements for higher engineering education (McKenna, Paretti, McNair & Hixson, 2014; Borrego, Froyd & Hall, 2010).

In 2010, China released the National Outline for Medium and Long-term Education Reform and Development (2010-2020). It is clearly stated in the outline that "It is necessary to follow the law of education and the law of talent growth, deepen education and teaching reform, innovate education and teaching methods and explore various ways of cultivation, to make men of talent come out in succession and top-notch innovative talents constantly emerge in large numbers". Innovation is the soul of a nation and the inexhaustible motive force of a country's prosperity and flourish. In the face of fierce international competition, independent innovation has become the main symbol of the core competitiveness of a country. Innovative talents have become the core of national talent strategy, and the cultivation of innovative talents has become an important historical mission of higher education in China. It is the core task of the current reform of higher engineering education to train and bring up a large number of engineers and technicians with innovative spirit, innovative consciousness and creative ability (Matusovich *et al*., 2014).

The cultivation of innovative talents has become an important research topic in higher engineering education in China, attracting a large number of scholars to carry out a series of theoretical researches and practical explorations, and some gratifying achievements have been made. Zhang, Wu, Liu & Wang, (2017), Gao and Cheng, (2013), Chen and Zhang, (2012), Xu, Zhang & Liu, (2011) strengthened the practical ability and promoted the cultivation of innovative talents, through the construction of practical teaching system and practical teaching platform. Yang and Chen, (2016), Shi and Li, (2014) constructed systematic discipline competition system and created a full range of academic competition platform, combing with professional features, so as to cultivate talents' practice and innovation ability through discipline competition, and good results have been achieved. Li and Lin, (2011) intensively studied the relationship between academic competition and practical teaching, and combined the two together to realize the cultivation of innovative talents. Ma, Zhang, Fan & Zeng, (2017), Chen (2015) proposed to carry out diversified second classroom activities, improve the operation of the second classroom mechanism, and built the first and second classroom teaching system to effectively improve the training of talent innovation ability. Gao, Teng & Li, (2012) proposed to improve the innovation ability of talents based on the laboratory opening. Cheng & Yang, (2011) explored the synergetic education mechanism based on school-enterprise cooperation through deepening school-enterprise cooperation and expand the depth and breadth of cooperation, which provided a new way for the cultivation of talent innovation ability.

These studies have played a positive role in the training of creative talents in engineering education from different aspects and angles, and have achieved certain results. But the training of innovative talents runs through the whole process of personnel training, and penetrates into all links and aspects of the teaching process. It is an organized, planned and complete educational activity and a complex system engineering composed of many internal factors. However, the above researches do not build the training mode of creative talents in engineering education from the view of a systematic point. Therefore, the author takes the cultivation of innovative talents as a system. The basic elements of the system, the status and role of the changing rules of all elements in the whole training of innovative talents, and the mutual influence and coordinated operation mechanism between various elements are analyzed, to make the elements co-develop and realize the training of innovative talents.

According to the analysis of the present situation and main problems of the training of innovative talents in higher engineering education in China, the "five-in-one" training mode of innovative talents was established based on the systematic theories. In-depth exploration to the internal factors of five subsystems and to the coordinated operation mechanism between systems has been carried out. Specific measures for training innovative talents in engineering education are put forward, which is of great significance for China to actively explore the training mode of innovative talents in engineering education in the new situation.

The connotation and requirement of innovative talents

The innovative talent is a compound specialized talent who has deep basic theoretical knowledge, solid professional knowledge, strong practical ability and is good to technological innovation. The innovative talent can creatively apply science and technology into production practice and is a carrier for transforming science and technology into practical productive forces, and is the main force for promoting the modernization of our country.

From the knowledge point of view, innovative talents have knowledge with a certain breadth and depth. On the one hand, its knowledge need to have a certain breadth. That is, the innovative talents not only have a certain theoretical knowledge but also have a strong theoretical skills; and it not only have a solid foundation of professional knowledge, but also have excellent applied abilities. On the other hand, its knowledge should be a certain degree depth, it finish the two transformations from practical requirement to solid foundation and from job skills to complete and systematic professional knowledge.

From a capacity perspective, innovative talents should have good practical ability and innovative ability. Innovative ability stems from practical ability, and practical ability is the basis of innovative ability; innovative ability is higher than practical ability and is a high degree integration of innovative thinking ability and practical ability. Analyzing the problem depends mainly on the thinking ability, and solving the problem depends mainly on practical ability, and analyzing and solving the problem requires the practical and innovative ability.

Current situation of innovative talents cultivation in higher engineering education in China

Weak innovative consciousness and lack of innovative thinking

In the traditional education dominated by examination-oriented education system, teachers do not attach importance to guiding and developing students' creativity, and even their innovation consciousness at the enlightenment stage is stifled. After entering the university, the students lack the consciousness of innovation and the initiative to participate in the innovation activities because of the inertia thinking and the blind obedience to the school education.

Lack of systematisms in the innovative talents cultivation system

The cultivation of innovative talents is an organized and planned education activity, which is a complex systematic project. It must comply with the systemization requirement to carry out the overall design and overall construction of the system. However, at present, most of the training of innovative talents has not set up a scientific and systematic innovative personnel training system from the perspective of innovation ability training, and lacks top-level design of innovative talents training.

The curriculum system and teaching methods do not adapt to the needs of innovative talents cultivation

Traditional curriculum system aims at cultivating students' ability to learn knowledge and comprehensive ability, and is not constructed with a view to cultivate students' innovative ability. In the course, the practicing and training of innovation ability cannot be fully reflected, and there is a phenomenon of emphasizing theory and dismissing practice. In addition, the "teacher centered" traditional teaching methods of "indoctrination" and "cramming" often fail to arouse students' learning enthusiasm, initiative and creativity, so they are not adaptive to the cultivation of innovative talents. Second, the curriculum is often set up in the same specification and with the same requirement at present. Therefore, all students are trained to be the same type of person with the same features. Students' personalities are not given into full consideration, and they are not provided enough chances to choose, which, to certain extent, stifles students' spirituality and creativity, and hinders the cultivation of innovative talents.

The role of second classroom activity in innovative talents cultivation is not given into full play

The phenomenon of paying attention to the first class and ignoring the second class is common. The relationship between the second class and the first class is not close, the degree of integration is not high, and a complete curriculum system is not formed. The form of the second classroom activities is monotonous, and the contents and methods need to be expanded and perfected urgently. The system of the second class is not perfect, and the activity mechanism needs to be further improved.

It is difficult for the mode of school-enterprise cooperation to form effective resultant force

The value orientation and social responsibility of various parties of school-enterprise cooperation are different. There is a lack of aspiration and long-term consideration of "co-construction, sharing and win-win" in their cooperation. The objectives of the cooperation of all parties are all intentionally or unintentionally "drawing on advantages and avoiding disadvantages". There is often a phenomenon of isolation from "production, learning and research". Besides, the coverage of school-enterprise cooperation is not extensive, the degree of participation of student is not high, and the depth and breadth of school-enterprise cooperation is limited. It is difficult for this kind of cooperation mode to form effective resultant effort to support innovative talents training.

The innovative talents training mode in higher engineering education in China

Construction of "five in one" innovative talents training system

It is necessary to construct such three curriculum modules as theoretical courses, practical courses and quality expanding courses, deepen theoretical teaching reform, strengthen the practice teaching link and set up all-around innovative teaching practice platform to cultivate innovative talents in engineering education, adhering to the concepts of student-orientation, focusing on foundation, respecting the choice, strengthening the practice and innovation and following such three principles of fundamentality, practicalness and individuation. It is imperative to establish the five-in-one innovative talents cultivation system on the basis of systematic theories, which takes classroom teaching as the basis, practical teaching as instrumentality, discipline competition as carrier, the second classroom activity as supplement and school-enterprise cooperation as expansion.

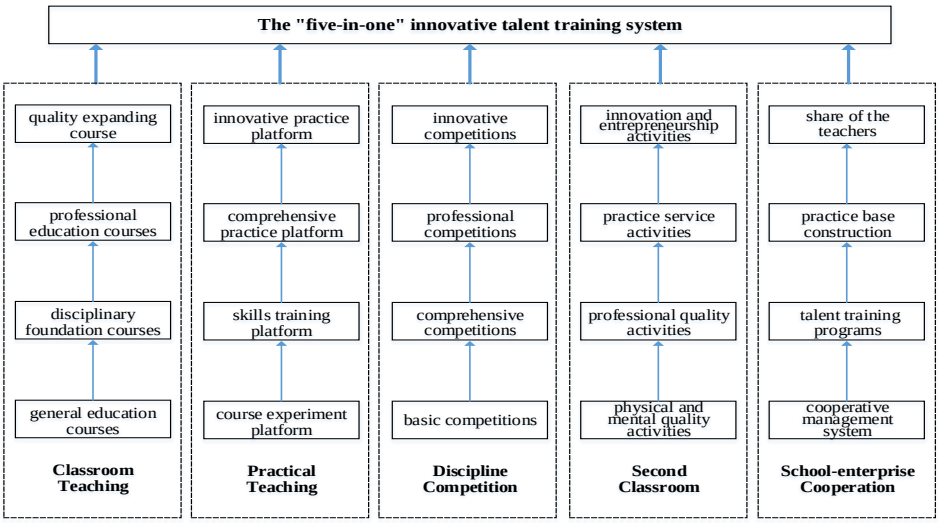

Figure 1. The "five-in-one" innovative talent training system

Classroom teaching is the basis for achieving the goal of training innovative talents. Cultivation of innovative ability relies on the basic theory, basic knowledge and basic skills of the professional. And then these knowledge, theory and skills come mainly from the course teaching.

Practical teaching is an important instrumentality for improving the innovation ability. Paying attention to teaching practice, strengthening the practice teaching and building a practical teaching system are effective means for achieving the innovative talents training.

Discipline competition is a carrier for achieving the goal of training innovative talents. Discipline competition is an important part of integrating the teaching inside and outside class, is the application and promotion platform of knowledge in class, and is an effective carrier to train innovative ability.

The second classroom is an effective supplement for the first class. The second classroom is the extension and promotion of the first classroom and is also an integral part of the college education. It not only broadens the horizons of students and stimulates their interest in learning, but also helps the students consolidate the knowledge learned in the class and cultivate the students' innovative spirit, innovative awareness and innovative ability.

School-enterprise cooperation extend the way and space of training innovative talent. Enterprises participate in the whole process of personnel training to further expand the depth and breadth of school-enterprise cooperation. The integration of production and teaching and cooperation education improve the innovative talent training.

Classroom teaching, practical teaching, discipline competition, the second classroom and school-enterprise cooperation are the five subsystems of the innovative talents training system. The five subsystems jointly support to achieve the innovative talents training by operating independently and interacting with each other.

Optimize the course system and reform the teaching method

Taking “innovative talents training” as the goal, and adhering to the organic combination of specialty range broadening and flexible setting of the major direction, organic combination of strengthening foundation and highlighting adaptability, organic combination of theory teaching and practice teaching, and organic combination of classroom teaching and extracurricular instruction, the author proposes to build a multi-layer progressive curriculum system which integrates the “general education platform, subject basis education platform, professional education platform and quality development platform".

The general education platform will set up practical course module while setting up theoretical courses, such as ideological and political theory education practice, and English network autonomous listening and speaking training. The basic discipline education platform shall increase the proportion of practical teaching modules, play its role in foundation course experiment, curriculum design, internship, and technical training and strengthen the cultivation of students’ hands-on ability. The practical teaching module in the professional education platform is designed for training students’ practical operational ability and practical working ability. It mainly arranges professional curriculum experiment, curriculum design, professional comprehensive

practice, production practice, graduation practice, graduation project, etc. The quality development platform introduces the innovation idea by expanding the scientific quality and cultural quality, strengthens the training of the hands-on ability and the spirit of innovation by expanding the students' basic quality in a certain discipline; develops students' professional quality, and cultivates their technical skills, professional skills, and innovative abilities.

In the curriculum system, professional direction classes shall be set, and the proportion of elective courses shall be enlarged, so that different students can make choice according to their own needs. The credit system shall be fully implemented to allow students to choose courses actively and flexibly, which breaks the "sweeping approach" in the curriculum design of previous scholastic year system. It allows students to fully participate in the teaching process. Students can not only choose learning contents, but also choose learning methods and teachers. This system provides a basis for the personalized development of students, and an educational environment for innovative talents training.

It is advised to apply a new generation of information technologies such as mobile internet, cloud computing, and big data to fully achieve the transformation from "teaching-oriented" to "learning-oriented", from "classroom-oriented" to "the combination of classroom teaching and extracurricular teaching" and from "result-oriented evaluation" to "the combination of result and process" through integrating the online and offline spaces. It is necessary to enrich the teaching methods, strengthen the interaction between teachers and students, strengthen the students' "learning ability", thus promoting the pace of innovative talents cultivation.

Optimize the practical teaching system and construct practical and innovative teaching platform

Creative talents must have innovative thinking, and innovative thinking cannot be created out of thin air. It depends on the training through practical teaching and the cultivation of practical ability. Practical teaching runs through the whole process and all aspects of the theoretical course teaching. Therefore, a multi-level three-dimensional innovative practical teaching system integrating "curriculum experiment, skills training, comprehensive practice and innovation practice" shall be established with a view to cultivate innovative talents. This system combines curriculum experiment and courses design with extracurricular innovation practice, and integrates basic teaching experiment, engineering practice and innovative design practice. Matching the theoretical curriculum system and curriculum content reform, this system focuses on design-type, comprehensive application-oriented and exploratory experiment and takes principle and function verification-type experiment as supplement. This practical teaching system progresses step by step. Therefore, multiple levels of practice from the shallower to the deeper, from simplicity to complexity, from passive imitation to active design, from basic experiment to improved experiment and then to innovative experiment are formed.

The practical teaching platform is an important carrier for cultivating college students' practical and creative ability. It is the "factory" which transforms theoretical innovation ability into practice innovation ability. It is a platform to cultivate college students' comprehensive ability and is an effective carrier to cultivate students' innovative ability. Efforts shall be made to strengthen student's hands-on ability and foster student's innovation ability through constructing the multi-angle and all-dimensional practical teaching and innovation platform

which focuses on "practical teaching, practice and training, innovative experiment and scientific research training".

Build innovation platform for discipline competition and improve the discipline competition system

The discipline competition measures the understanding, organization and utilization of knowledge among students. Unlike conventional teaching, the competition provides a unique way to enhance the practical competency and innovative mind of college students (Yin and Xiao, 2009). Efforts shall me made from the following perspectives: Setting up multi-angle all-dimensional discipline competition innovative platform with distinct features, establishing the long-acting working mechanism of the discipline competition and vigorously promoting the cultivation of innovative talents; founding special discipline competition management organization and constructing discipline competition management platform; establishing an open creative laboratory and innovative practice base to form a practical platform for discipline competition; combining the series professional courses setting with discipline competition special training to build a training platform for discipline competition; forming a student research team and vigorously implementing innovation project of college students to construct the scientific research platform of discipline competition; participating in all kinds of discipline competitions and hosting competitions independently to found the testing platform for discipline competition; propagating excellent students and their competition works to establish the display platform for the results of the discipline competition; improving the running mechanism of the discipline competition to enhance the discipline competition system platform.

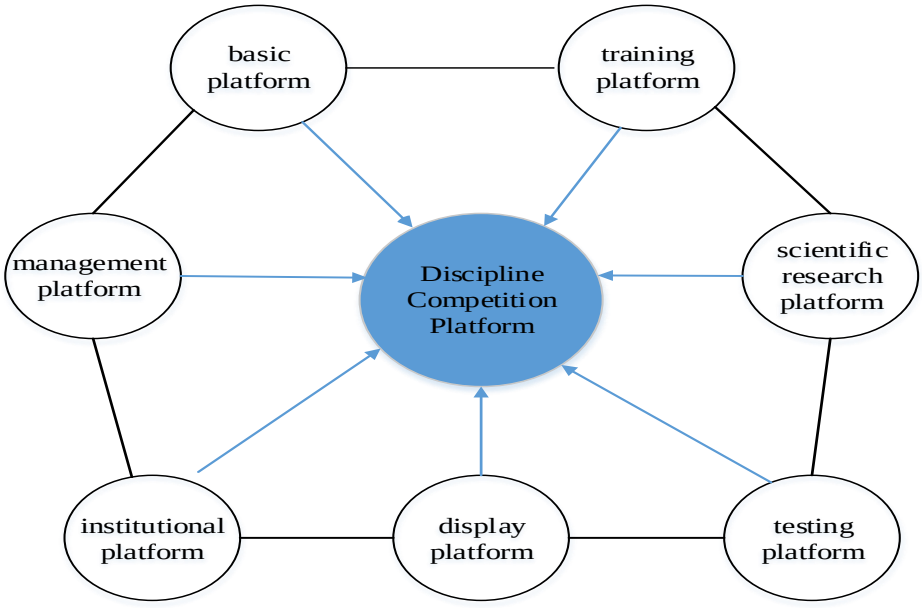

Figure 2. Discipline competition platform

The role of the discipline competition platform shall be further brought into play and it is imperative to establish a multi-level and all-dimensional discipline competition system composed of four stages, four levels, four categories and three capacities to constantly improve the innovative personnel training quality (Zeng & Zeng, 2012).

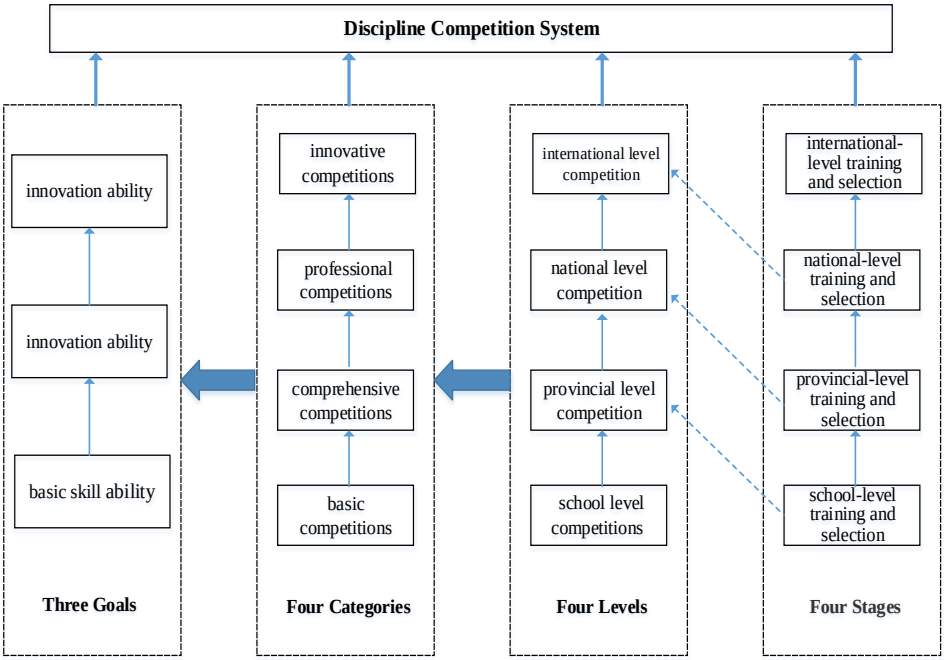

Figure 2. Discipline competition system

Improve the second classroom activity mechanism

The second classroom activity is different from the first classroom activity. They cooperate with each other. The second classroom activity consists of a series of open-ended activities, with cultivating innovative talents as the aim, training students' basic skills and improving students' comprehensive quality as the key point, fostering students' innovation capacity as the core and rich resources and space as the carrier. As the supplement and continuation of the first classroom activity, the second classroom activity makes up the complete education system together with the first classroom activity. Efforts shall be made in the following aspects: creatively integrating the second classroom activity into the first classroom teaching activity in combination with the professional characteristics and social needs to form an integrated curriculum system; constantly enriching the second classroom content, improving students' cultural quality through cultural, sports and art activities and enhancing their academic research ability, professional skills and social practice; with the university student associations as the carrier, improving the associations management level and establishing long-acting operation mechanism to constantly arouse students' consciousness of innovation; further broadening the field of practice

and cultivating student's consciousness of meeting the challenge, innovation spirit and comprehensive competitive ability through the university student social practice base; strengthening the construction of college students campus culture and creating a positive and strong learning atmosphere to create a nurturing environment for creative talents; establishing reward mechanism and operation mechanism to ensure the normal and efficient operation of the second classroom activity.

Improve all-round synergetic education system based on school-enterprise cooperation

Focusing on cultivating students' comprehensive quality and capacity, the education mode based on school-enterprise cooperation is the one which combines school education with the production and scientific research practice. The school education stresses classroom teaching, while students can directly obtain engineering knowledge, innovation capacity and practical capacity in the production and scientific research practice. In this mode, various education resources of schools, enterprises and scientific research units are used and their respective advantages in talent cultivation are given full play. The objective of this new mode is to cultivate innovative talents with coordinated knowledge, capacity and quality and adapting to social needs.

A shared type of collaborative education practice platform integrating education, training and research and development needs to be established with the market demand as the guidance, and enterprises as the subject, centering on improving students' engineering practical capacity and application innovation capacity and gathering the advantageous resources of industry departments, scientific research institutions and enterprises. Meanwhile, a team composed of double-professionally-titled teachers shall be established. The synergetic education system based on school-enterprise cooperation shall be established through co-establishing the sharing system, personnel training program, curriculums and teaching materials, and innovation and practice bases, mutual recognition of credits, joint guidance, evaluation, innovation and entrepreneurship, and development, integrated production and teaching, teacher exchanges to constantly enhance cooperative education mechanism and provide new path and expand the education space for cultivating innovative talents.

Conclusion

China has the largest size of engineering education in the world. Its higher engineering education reform will have an important impact on the education worldwide. It is the important historical responsibility of China's higher engineering education and the key and fundamental of innovation talent cultivation in colleges and universities to create good training conditions for innovative talents cultivation through changing the unfavorable factors for innovative talents cultivation of the higher engineering education teaching mode, construct application-oriented innovative personnel training mode, vigorously train engineering and technological innovation and industrial innovation talents, transform and upgrade the service industry. It enables China to shift the focus of engineering education from quantity to quality.

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