TEACHING REFORM OF COMBINING INNOVATION ABILITY TRAINING WITH ENGINEERING EDUCATION

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ABSTRACT

In today's world, the cultivation of innovative and entrepreneurial talents has become a key factor affecting the country's core competitiveness. Innovation and entrepreneurship education is becoming a brand-new model pursued by higher education. However, most colleges and universities only work hard to continuously build and improve the innovation and entrepreneurship curriculum system. However, there is no good solution for how to integrate the cultivation of innovation and entrepreneurship ability with engineering education, and how to integrate the cultivation of innovation ability with industry needs. Faced with this problem, this article explores a set of teaching reform solutions that integrate innovative and entrepreneurial thinking and methods into professional practice courses. In the practice of professional courses, it collects real industry needs from school-enterprise cooperative enterprises, guides students' innovation direction and goals, and introduces TRIZ innovative methods to improve the level of innovative design. At the same time, the company's project implementation process and management methods are introduced into the practical training to improve the quality of the results in the design concept and system realization stage, and effectively enhance the students' innovation motivation and practical ability. Through the verification of the pilot course, this teaching reform method can effectively integrate innovative and entrepreneurial thinking methods with the majors learned, enhance the students' teamwork and knowledge integration and application capabilities, and can significantly improve the level of innovation in practical courses.

KEYWORDS

Cultivation of Innovative Ability, Innovation and Entrepreneurship, Engineering Education, CDIO, TRIZ Application, Standards: 1, 3, 4, 5, 7, 8

1. BACKGROUND

With the vigorous development of artificial intelligence and automation technology, industries with traditional repetitive labor are facing unprecedented challenges in terms of employment. Innovation and entrepreneurship have become an inevitable requirement for the sustainable development of human society. Throughout the world today, innovation and entrepreneurship education has become a brand-new model pursued by higher education. The national core competitiveness is increasingly manifested in the effective development, cultivation, allocation and regulation of human resources. The development and training of innovative and entrepreneurial talents has become the key to the country's core competitiveness(Liu, 2011).

The report "Higher Education in the 21st Century: Outlook and Action World Declaration" published by UNESCO in 1998 pointed out that in addition to traditional academic and

vocational education, young people in the 21st century should have a third education passport. That is, entrepreneurship education, it was at this conference that the concept of entrepreneurship education was formally put forward. The United States is the first country to carry out innovation and entrepreneurship education. It has incorporated entrepreneurship education into the national education system and covers the entire process from elementary school to graduate education. Entrepreneurship education courses have been generally offered in its colleges and universities (Tao, Yu, & Zhang, 2010). The British government also has the "Enterprise in Higher Education Initiative" (EHE) plan (Zhang, 2010), and the German government put forward the slogan "To make universities a melting pot of entrepreneurs" (Xia, 2014). Japan, Singapore, China and other regions in Asia are also actively promoting innovation and entrepreneurship education. It can be seen that innovation and entrepreneurship education has attracted widespread attention from all countries and regions in the world, and innovation and entrepreneurship education has become a new trend in international education and an important part of modern education, especially higher education.

2. ANALYSIS OF INNOVATION AND ENTREPRENEURSHIP EDUCATION

Paying attention to the current implementation of innovation and entrepreneurship education in China, there are still many unsatisfactory places in terms of educational effects and achievements. Colleges and universities that started relatively late inevitably have the problems of blindly following the trend, imperfect curriculum system, and vague curriculum content. Even colleges and universities that have implemented innovation and entrepreneurship education for a long time still have the problem of isolation between innovation and entrepreneurship education and professional education, and insufficient training of innovative practice capabilities within the profession.

First of all, the efforts made by the vast majority of colleges and universities in innovation and entrepreneurship education are continuous iteration and improvement in the construction of curriculum system and curriculum content. Although students can master the general innovative thinking and innovative methods, it is difficult to combine innovation practice with professional education and make effective innovative achievements in professional fields. The main reason is that the innovation and entrepreneurship curriculum system and the professional curriculum system are set independently of each other, the innovation and entrepreneurship ideas are not integrated into the professional education, the professional curriculum is still in accordance with the traditional teaching mode, the implementation process and steps of innovation methods are not fully considered in the curriculum content and teaching links, and the training of professional innovation and practice ability is lack.

Secondly, in the teaching of professional courses, the practical content is seriously out of touch with the development of the industry, the course cases are outdated. Therefore, the content of professional practice courses should keep pace with the times, and each round of teaching should update the latest technology and industry demand information into the classroom. Innovation and entrepreneurship training also requires innovative ideas based on the latest industry needs nowadays in order to make the practical content more innovative, practical and entrepreneurial.

In addition, if students only have good innovative ideas and cannot be realized, the ideas will lose their meaning and they will not be able to fully exercise their innovative practical ability. How to carry out teamwork in the implementation process and how to use efficient engineering processes and management methods to achieve high-quality completion of the project is also

crucial. The operating mechanism of an enterprise is the best example in this regard, so introducing enterprise elements is the best way to integrate the classroom with society.

3. REFORM SOLUTION

Aiming at the problems of insufficient cultivation of innovation and practice ability, the isolation of innovation and entrepreneurship curriculum system from professional curriculum system, and the isolation of professional practice curriculum content from industry demand, this paper explores a set of teaching reform scheme of integrating innovation and entrepreneurship thinking and methods into professional practice curriculum. Through the point to area effect, improve the level of innovation and entrepreneurship practice education of the whole engineering specialty. The reform contents are as follows.

3.1 Integration of Innovative Methods and Practical Design Links

In order to solve the problem of lack of innovation and let innovation have a law to follow, innovative methods, namely TRIZ (Inventive Problem Solving Theory) innovation methods, are introduced in the practice links of professional courses. TRIZ is an innovative problem-solving theory invented by the former Soviet Union. After more than 60 years of development, a mature theory and method system for solving technical invention problems has been formed (Jing & Huan, 2005). According to the process requirements of TRIZ innovation theory, professional courses redesign the conception and design of CDIO, leaving room for the application of TRIZ method, and improving the innovation level of system conception and the rationality of the design.

3.2 Develop Practical Project Goals Based on Corporate Needs

In order to make practical innovation more practical and entrepreneurial potential, this article introduces corporate needs in the formulation of practical project goals, uses many professional-related corporate resources in the corporate practice base, and collects project requirements from companies, which can be products that companies are making. Either the technical content, or the business direction that the company plans to expand. After decomposing and filtering the actual needs of the enterprise, it is introduced into the practical teaching process of professional courses to ensure that the training of professional skills closely follows the needs and development of the industry.

3.3 Configure Corporate Mentors for Practical Projects to Improve Practical Ability

In the project implementation phase, in order to ensure the project quality, cost and time engineering requirements, in the classroom simulation of enterprise organization methods in project development and management. If conditions permit, enterprise mentors can be introduced from school enterprise cooperation enterprises to form a "double tutor" system. Enterprise tutors are mainly involved in the demand formulation, design review, achievement quality review and other stages of practical projects, aiming to introduce industry demand, enterprise development process, quality requirements and evaluation methods of achievements into the curriculum, so as to ensure the quality of practical achievements and ensure that students' ability training meets the requirements of enterprises.

4. IMPLEMENTATION OF REFORM PILOT CASES

Our school has been implementing innovation and entrepreneurship education since 2002, and has accumulated nearly 20 years of innovation and entrepreneurship education. The experience and existing problems in this area are very representative. This article takes the professional practice course of "Vehicle Information Technology Practice" as a pilot, and specifically implements the reform measures that integrate the cultivation of innovative practice ability and professional engineering practice ability, including the following aspects of implementation content.

4.1 Integrating TRIZ Innovation Method into Practice

According to the process of CDIO Engineering Education, the practice is generally divided into four stages, namely, conceive, design, implementation and operate. This process is more suitable for the process of engineering design and implementation in the case of clear development requirements. The most important thing that determines the innovation of a practical work is to establish the project objectives and analyze the solutions in the first two stages, and TRIZ method is best at solving the problems by using the completeness rule to find the solutions for specific scenarios (Chen, Jang, & Lu, 2015). This requires more innovation and design work in the Conceive stage and Design stage. In the course design, teachers should set aside corresponding class hours for TRIZ scheme deduction. The flow chart of TRIZ problem-solving process and CDIO process integration is shown in Figure 1.

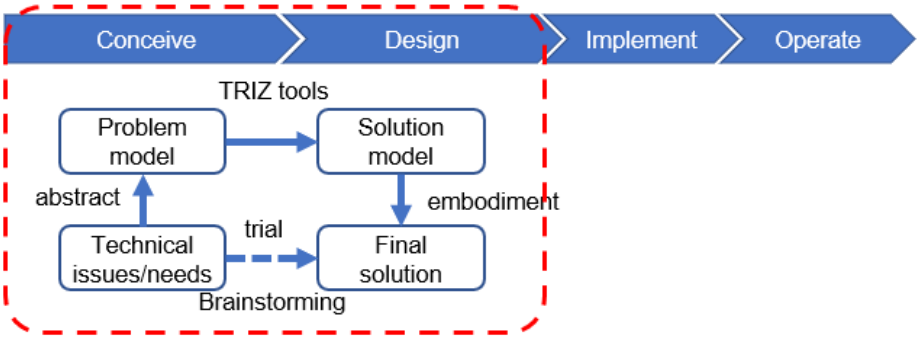

Figure 1. TRIZ Problem Solving Process and CDIO Process Integration Diagram

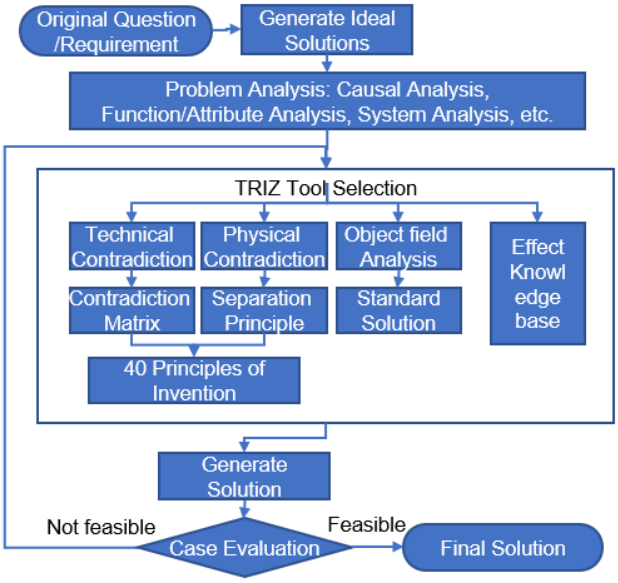

Figure 2. TRIZ Method Problem Solution Deduction Flow Chart

When using TRIZ for innovative design, the core process is to analyze the problems or requirements that need to be solved, abstract special problems into general TRIZ problems, and then apply TRIZ tools to find solutions based on the corresponding problem models. This process may require Repeated program evaluation until the optimal solution is found (Guan & Zhu, 2015). The detailed process of using the TRIZ method is shown in Figure 2. In actual problem solving, the process of abstracting the essence of abstract problems and correctly applying TRIZ tools to obtain reference solutions is the focus of practical training.

Here are two practical application examples in the course. The first example is that there is a function that allows the driver to sense the temperature outside the car. Students can easily think of using the temperature sensor to collect the temperature and display it on the electronic dashboard. But in fact, this is not a very good design, because a lot of status information has been densely displayed on the dashboard of the car. If it is displayed in the form of numbers, the driver needs to be very careful to see it clearly, which is very distracting to the driver. So, how can design be better? We try to use TRIZ Method to solve the problem below.
First of all, the contradiction in the problem is extracted. It is not difficult to find that there is such a pair of contradiction. For safety, the driver wants to get the temperature information in less time, but it leads to the loss of information because he can't see clearly. Therefore, we use this pair of contradictions to find the answer in the contradiction matrix, which can correspond to the No.25 waste of time and No.24 loss of information. No.25 is the optimization parameter and No.24 is the degradation parameter.

Two groups of parameters are queried in the contradiction matrix, and four reference solutions are obtained, which are No.24 intermediary, No.26 copy, No.28 replace mechanical system and No.32 change color from the 40 Principles of Invention. Please refer to figure 3.

Finally, each group of solutions is brought into the application scenario of the problem to find the appropriate solution. In this case, the best solution is No.32 change the color, that is to change the color of the digital dashboard screen according to the temperature. As long as the driver can sense the temperature change according to the color change of the dashboard. But the rest solutions are not suitable.

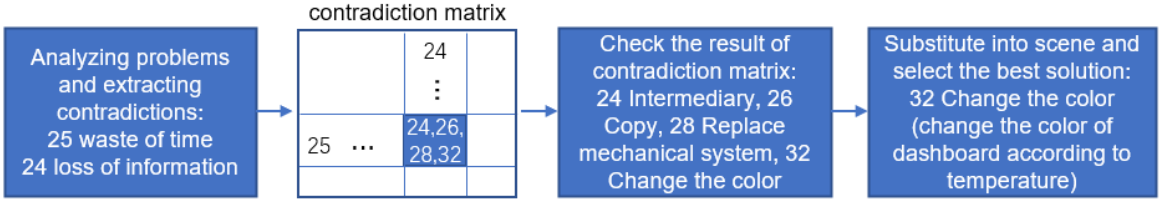

Figure 3. application process of TRIZ Method in temperature case

Another example is the use of face recognition technology to confirm the driver's identity, in order to automatically adjust the seat position, air conditioning temperature and other parameters. In the scheme design, students encounter such a problem, if the driver has not been on the car, the face recognition function will continue to recognize, because the face recognition algorithm consumes processor performance, which brings the problem of performance waste. In the face of this software problem, we find the contradiction between improving No.38 degree of automation and No.22 degree of energy waste, and finally find the method of introducing feedback to solve the problem by using the contradiction matrix of TRIZ.

The TRIZ method is certainly an advanced method in guiding innovative thinking. However, if specific application scenarios and specific requirements are not provided, it is difficult to produce valuable innovative works out of thin air. Therefore, in order to make practical works more scene-oriented, it is necessary to combine the following second content to establish project goals.

4.2 Collect Real Needs of Enterprises and Guide the Direction of Innovation Based on The Framework of School Enterprise Cooperation

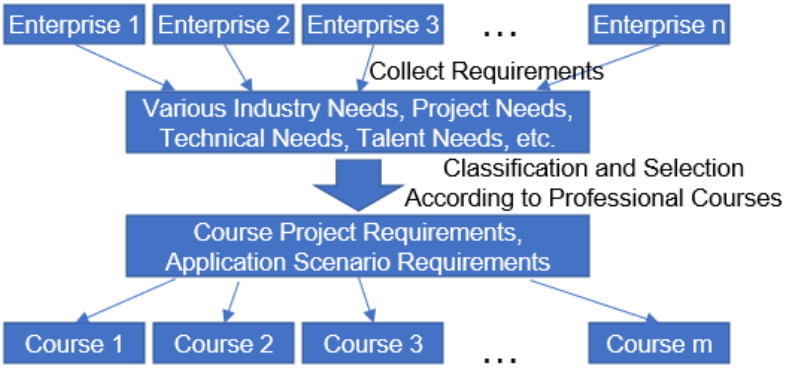

Figure 4. Flow Chart of Project Requirements for Courses Collecting from Enterprises

The topic selection of practice project is the key to guide innovation. If the teacher specifies the topic, it will focus on the project design and implementation, which limits the students' innovative thinking. On the other hand, if students are allowed to choose topics freely, they will go to the other extreme. Either the goals set are too ambitious to achieve, or they have no practical value due to lack of industry background knowledge.

Table 1. Demands of Enterprises in the Direction of Automotive Electronics

category	requirements content
Business requirements	Mobile app and vehicle machine interconnection, people find the car, car track record, dynamic electronic instrument panel, intelligent driving assistance, driving safety detection, Car perception of people, human machine interaction, other innovative functions
Technical requirements	Solid C language foundation, Linux system, data structure, Android development, Qt development, basic hardware knowledge, problem solving ability
Management requirements	Understand the development process, have documentation capabilities, quality and cost awareness
Cooperative communication	Good communication, division of labor and cooperation, responsibility, and strict delivery

In this project, the topic selection method of practice project is reformed, and the enterprise resources related to many majors in the enterprise practice base are utilized. According to the process of Figure 4, the curriculum project requirements are collected and refined. First of all, collect project demand, industry demand, technology demand and talent demand from the enterprise, which can be the product or technology content that the enterprise is working on, or the business direction that the enterprise plans to expand. Then the teachers of professional

courses will filter and screen the collected demands, and classify, summarize and sort them according to the course contents, so as to form the project demands suitable for the course. In this way, it is meaningful for students to use TRIZ to determine the practical design objectives. Such a guided innovation will help students' achievements not only meet the professional requirements of the course, but also have value in the application of the industry. As shown in Table 1, it is the enterprise requirements collected and sorted out in the course practice of "vehicle information technology practice".

In terms of implementation procedures, the program can take advantage of the existing school-enterprise cooperation framework to collect corporate employment needs every year and issue a demand-collection questionnaire to the company to obtain corporate demand information. The formation of annual operating regulations in this way can ensure that the school grasps the latest corporate demand trends, and guide the teaching goals of the courses accordingly. Naturally, the teaching content of our school can keep up with the pace of the times and always maintain fresh vitality and competitiveness.

For the enterprise, the new direction that the enterprise wants to try to develop is combined with the school through the school-enterprise joint method, and the student's innovation results are fed back to the enterprise, which has great mutual win value for the enterprise's selection of talents and product trials.

4.3 Set Up Enterprise tutor to Introduce Enterprise Processes and Standards into Classroom Practice Projects

Our school has accumulated a lot of school enterprise cooperation resources in enterprise practice base and scientific research cooperation. In this case, we invite experienced engineers from the school enterprise cooperation enterprises as enterprise tutors, and form a double tutor system with school professional teachers. The technical backbone of an enterprise or the person in charge of human resource recruitment mainly participate in the demand formulation of practical projects, the evaluation of intermediate achievements, and the evaluation of project achievements, as shown in Figure 5. From the perspective of the enterprise, the enterprise tutor reviews the students' achievements, points out the problems, introduces the practices of the enterprise, and puts forward suggestions for improvement.

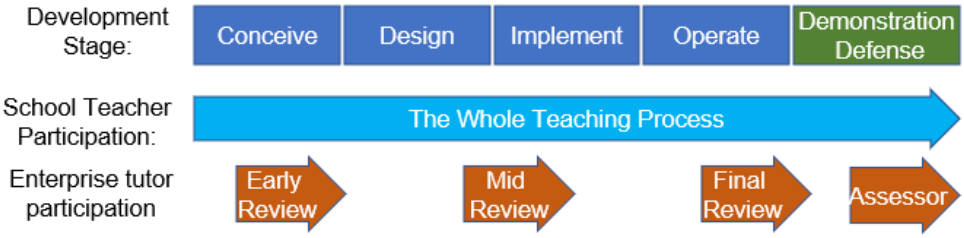

Figure 5. Schematic Diagram of Corporate Tutors Participating in Courses

Through the enterprise tutor, we can further obtain the industry demand of the enterprise's field, and set up the evaluation link for the enterprise tutor to participate in in the middle of the course or the final results display link, so that students can understand the requirements, development process and evaluation standards of the enterprise, which is conducive to students to understand more information of the enterprise before graduation, and can stimulate students to learn Students learning enthusiasm, can also get more relevant industry background knowledge.

For the employers of enterprises, they can understand the learning content of students and pay attention to the talents meeting the needs of enterprises in advance, and also introduce the enterprise's talent training content to the school teaching stage in advance, which greatly shortens the training time from graduates to enterprise employees, and reduces the enterprise's talent training cycle and cost.

Combining with the enterprise development process to refine the course project process and clarify the requirements of the achievements in each stage, students can learn more process principles and the correct production methods of the achievements in each stage in practice. So that they can complete the development of the achievements according to higher quality standards. On the other hand, they can cultivate the habit of completing the project according to the development process and methods. Table 2 is the corresponding table of development stages and achievements of embedded software development projects in the course practice.

Table 2. Development Stage and Result Material Correspondence Table

Stage	Development content	Achievements
Conception design	Demand survey and feasibility analysis Do outline design and review Develop project plan	Requirements specification book Summary design book Project plan
Detailed design	Detailed design: UI design, module design, process design Detailed design review Test case design and review	Detailed design book Test pattern book Issue management table
Coding implementation	Coding and debugging Code review Combination test	Source code Issue management table
System testing	System testing and debug System test review Result collation and data preparation	Bug management table Test result book Software publishing reports and materials

5. REFORM EFFECT AND SIGNIFICANCE

The implementation of this curriculum reform fully integrates the cultivation of College Students' innovative practice ability with the training of professional practice ability, and has achieved good reform effect. If the enterprise's evaluation criteria for talents are summarized into five aspects, with a full score of 10, the comparison results shown in Figure 6 can be obtained.

(1) Basic knowledge: the focus of this reform program is to improve the ability of innovation and practice, so there is no obvious effect on the improvement of basic knowledge.

(2) Problem solving: due to the introduction of enterprise management methods, the project division is more clear, and TRIZ method is used to assist analysis, which promotes students' ability to analyze and solve problems independently, from an average of 7 points to 8 points.

(3) Management process: there is almost no project management in the original course, so the introduction of enterprise project management and development process has played a significant improvement effect on the orderly promotion of the project and risk prevention.

Although students cannot fully understand the necessity of some process settings, they have also achieved a good score from 5 to 7.5.

(4) Scheme design: due to the introduction of TRIZ analysis method and project development process, as well as increasing the proportion of class hours in the design process, the rationality and standardization of scheme design have been greatly improved, from 7.5 to 9.

(5) In terms of innovation and creativity: the introduction of TRIZ Method and the increase of the proportion of class hours in the conception stage significantly improved the innovation effect, from 6 points to 8.5 points.

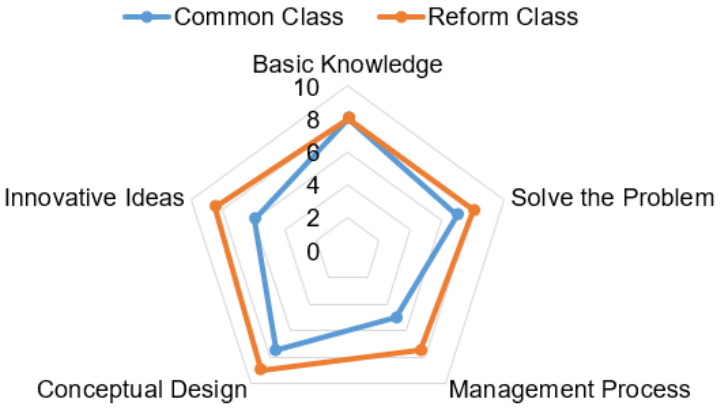

Figure 6. Radar Chart of Teaching Effect Contrast

The starting point of this reform program is in line with the concept of Outcomes-based Education (OBE), and it is oriented to the needs of enterprise talents and society for innovative and entrepreneurial talents. It effectively solves the problem of separation between innovation and entrepreneurship education and professional education.

(1) In the aspect of integrating theory with practice, this paper puts forward the innovation of practical methods, and integrates TRIZ method based on theory teaching into professional practical courses.

(2) In terms of the use of school enterprise cooperation resources, this paper puts forward the innovation of win-win utilization of resources, uses the existing school enterprise communication channels to collect enterprise needs, provides information channels for guiding curriculum practice objectives, shares curriculum innovation achievements with enterprises, and also provides innovative ideas and inspiration for enterprise product innovation.

(3) In the practical guidance mode, the innovation of "double tutor" system is put forward, which can invite enterprise personnel to participate in the practice, improve the quality of practice results, promote mutual understanding between school and enterprise, and form a virtuous circle of school enterprise cooperation.

6. CONCLUSION

In the cultivation of innovation and practice ability, the reform measures enable students to experience the whole process from creative conception to concrete realization by means of engineering technology. In the short term, it can improve students' innovation and practice

ability and the innovation level of practical courses. In the long run, from quantitative change to qualitative change, the improvement of innovation ability will inevitably lead to excellent entrepreneurial achievements, so as to promote more employment and relieve the social employment pressure. Finally, the real purpose of education serving the society and creating students' value is achieved.

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