

Construct Integrated Teaching System and Cultivate Excellent Engineering Innovative Talents

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Abstract—According to the demand for applied innovative talents of the railway industry and enterprises, based on the railway specialized characteristics advantage of the East China Jiaotong University, and in accordance with the system engineering thoughts as “setting training objectives, setting up training standards, building course system, reforming teaching methods and perfecting security system”, a new integrated teaching system is built and put forward. This integrated teaching system is composed by the integration of the training objectives, cultivation conception and curriculum system, the integration of the course system, teaching methods, learning methods, evaluation methods and continuous improvement, and the integration of knowledge, ability and quality cultivation. By now, this teaching system has been implemented in the Excellent Engineer Education Training Plan pilot in Vehicle Engineering major of East China Jiaotong University, and has achieved significant results.

Keywords—Vehicle Engineering; Teaching System; Integrated; Excellent Engineer Plan

I. INTRODUCTION

As a major project organized and implemented under *the Outline of the National Medium-and Long-Term Programmer for Education Reform and Development (2010-2020)*, the core objective of the “*Excellent Engineer Education Training Plan*”(hereafter referred as Excellence Plan) is to build the talent training standards, reform the talent training mode, build a high-level engineering education teachers team, expand opening up and strive to develop and enhance the students’ engineering literacy, engineering practice ability, engineering design ability and engineering innovation ability, Which will be supported and achieved by closed industry-university cooperation and learning the historical achievements of our country’s engineering education and the successful experience of advanced countries and making use of the opportunity of China’s new Chinese-characteristics industrialization and guided by the demand of industry and enterprises and based on engineering practice background and engineering technical [1].

The Vehicle Engineering major of the East China Jiaotong University is a pilot major of China’s Ministry of Education and Jiangxi province’s “Excellence Plan”. And a new integrated teaching system of the vehicle engineering is

built by broken through the limitations of the existing undergraduate education, and according to the system engineering thought (as shown in Figure 1) as “setting training objectives, setting up training standards, building course system, reforming teaching methods and perfecting security system”, and the demand for vehicle engineering applied innovative talents of China’s rapidly developing railway transportation industry, and based on the advantage of East China Jiaotong University’s railway specialized characteristics.

This integrated teaching system is composed by the integration of the training objectives, cultivation conception and course system, the integration of the course system, teaching methods, learning methods, evaluation methods and continuous improvement and the integration of knowledge, ability and quality cultivation. Under this integrated teaching system, innovative and pragmatic applied talents those who have strong practice ability in the design, manufacture, application, maintenance and production technical management of the railway vehicles and related product can be cultivated for the railway transportation industry and urban rail transportation enterprises.

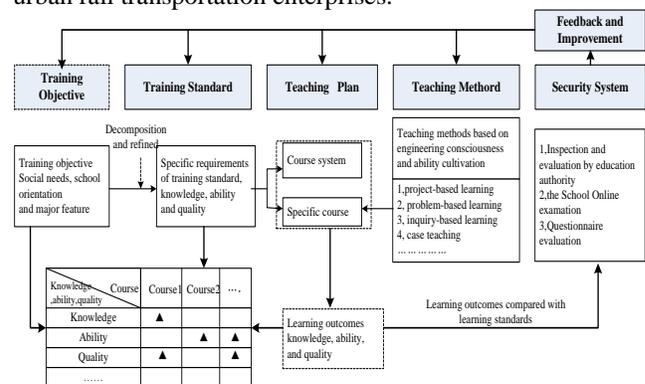


Figure 1. The general thought of the Vehicle Engineering “Excellence Plan”

II. THE DETAILED AND REASONABLE TALENT TRAINING OBJECTIVE

As is known to all, the talent training objective can generally be divided into three levels, such as type objective, major objective and competences objective [2]. Among the three objectives, the type objective determines the type

attribute, type characteristics and type orientation of the talent training, while the major objective defines the major attribute, major characteristics and major orientation of the talent training and the competences objective is a concrete objective to realize the type objective and major objective. Thus, the talent training mode is constituted by the way to realize the three training objectives naturally.

It is known that the life cycle of a project or product can be divided into four phases as service, produce, design, and research, this four-phase division is also applicable to each engineering discipline and major, and in each phase it has its own outstanding requirement of engineer's responsibility and ability which are clearly different from other phases. Therefore, engineers in different phases can be called service engineers, produce engineers, design engineers and research engineers respectively [3]. The applied innovative talents cultivation is aim to cultivate service engineers and production engineers, namely to cultivate applied talents those who have strong innovative sense and practice ability in the design, manufacturing, marketing and service, or project construction, operation and maintenance for the railway industry and related enterprises. East China Jiaotong university is a local general university with railway transportation industry characteristics background, the training objective of its Vehicle Engineering major is to cultivate applied innovative talents, namely to cultivate applied innovative talents those who have strong innovative sense and practice ability in the design, manufacture, application and maintenance and production technical management of the railway vehicles and related products for the railway transportation industry and urban railway transportation enterprises.

The purpose of the engineering education is to provide students with special technology, social consciousness and innovative spirit and make them become successful engineers. Explored, researched and founded by Massachusetts institute of technology and Sweden's royal institute of technology and other two universities, the CDIO(conceive, design, implement and operate) engineering teaching concept is the latest results of the international engineering education reform in recent years. The CDIO concept not only inherited and developed the engineering education reform concept of the Europe and the United States over the years, more important is that it put forward the standards of systematic ability training, comprehensive implementation guidance, complete implementation process and strict result inspection, and has strong operability [3-5].

As the guidance document of the CDIO engineering education, the CDIO outline covers the science and technology knowledge, ability and quality that a modern engineer should have. In the CDIO outline, the engineering graduates' knowledge and ability is divided into engineering foundation, personal ability, interpersonal teamwork ability and engineering system ability four aspects. And the outstanding characteristic of the CDIO outline is its detailed content and strong operability. According to the common standards of the "Excellence Plan", the needs of the railway industry and the orientation of East China Jiaotong University, in the vehicle engineering "Excellence Plan", the

four training objectives of the CDIO outline are detailed into 23 segments to define the characteristics objective of the vehicle engineering major, as is shown in Figure 2.

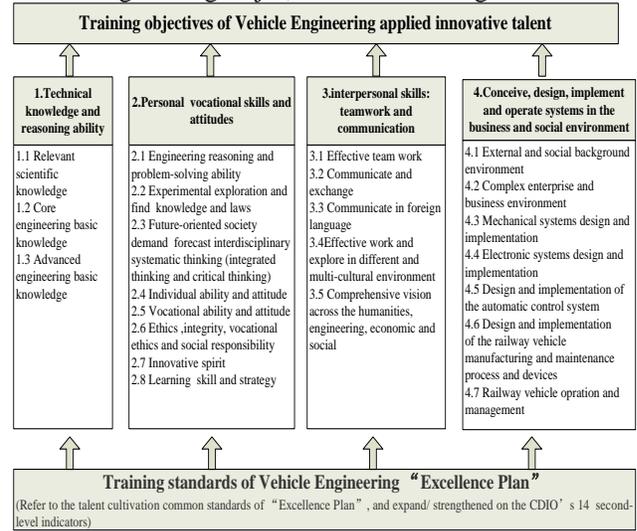


Figure 2. The training standard of the vehicle engineering "excellence plan" based on CDIO outline

III. INTEGRATED COURSE SYSTEM BASED ON ENGINEERING ABILITY CULTIVATION

According to training objective, defining the knowledge, ability and quality students should learn, and through course integration and based on engineering ability and engineering consciousness cultivation, the integrated course system of vehicle engineering major can be constructed.

A. The "Big Major and Small Discipline" Course Structure for Engineering Ability Training

Based on the engineering ability training objective, the course framework of the Vehicle Engineering "Excellence Plan" is constructed according to the "big major and small discipline" course structure. As shown in the Figure 3, the course framework includes three platform courses: public basic platform courses, specialized basic platform courses and specialized direction platform courses. Among them, the course system of the "big major platform" (include public basic platform courses and specialized basic platform courses) is charged with the task of general education and professional enlightenment education, and this course system is set up based on the social overall quality specification requirements of engineering technical talents. The courses set by "big major platform" are some general public basic courses and basic knowledge courses of this major, so as to cultivate the engineering talent's basic knowledge and basic skill of this major, and reflect the general education function of the "big major platform".

However, the "small discipline" module (specialized direction platform courses) is set up according to the social needs, and the big major can be detailed into different disciplines to make professional direction more clearly, the professional education more deeply and keep up with the

development of the discipline. The “small discipline” module courses are formed by theory courses and practical courses

with professional feature, thus to cultivate the student’s further professional skills of the discipline direction.[6-7].

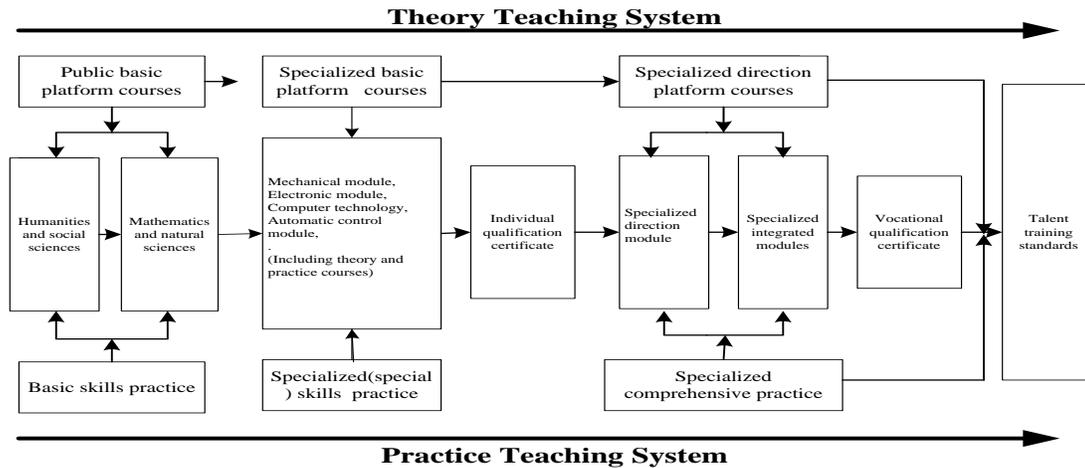


Figure 3. Figure 3, The “big major and small discipline ” course framework of vehicle engineering

B. Course Integration and Reconstruction Based on Engineering Techniques and Ability Cultivaion

Courses are the main carrier of a university’s talent cultivation, and the method to achieve the education objective. Moreover, the training objective determined the content and structure of the course, therefore, the course must be set and instructed based on the training objective[7-8]. The objective of the “Excellence Plan” is to cultivate engineers with multi-discipline knowledge background and strong practical ability, and it is that objective determined its course setting must fit the actual demand of the social engineering.

With the aim to cultivate applied innovative talents, and through courses integration which based on engineering technology and ability, an applied, comprehensive and practical course system is constructed in Vehicle Engineering major of East China Jiaotong University.

1) *applied integration of the course*:As shown in Table 1, the research courses in the original course system are integrated as applied courses according to the applied innovative talent training objective.

TABLE I. APPLIED INTEGRATION OF THE COURSE

Research courses in the original course system	Applied courses in the course system	Notes
Vehicle system dynamics, Vehicle strength calculation, Vehicle design theory	Vehicle engineering introduction, Train network control technology, Vehicle operations, Vehicle manufacturing and repair process design	comply with the training objective of the applied innovative talent cultivation

2) *Comprehensive integration of the course*:The engineering education is emphasizes on synthesized using knowledge to solve practical problems, and requires universities to integrate the knowledge and content of the engineering courses, thus to establish engineering comprehensive teaching modules from the starting point of solving complex engineering problems and in accordance with the engineering technology and skills, and develop student’s deep engineering knowledge. The comprehensive integration of vehicle engineering courses is shown in Table 2 as follows.

TABLE II. COMPREHENSIVE INTEGRATION OF THE COURSE

No	Courses before integration	Courses after integration	Notes
1	Vehicle manufacture process and device, Vehicle engineering (Vehicle structure and principle), Vehicle maintenance process and device	Vehicle Engineering	Integrate course content in favor of (structure-manufacture-maintenance) project-based teaching
2	Foundation of Control Engineering, Matlab and its engineering applications	Foundation of Mechanical Engineering Control	Use the Matlab software for control engineering simulation
3	Electromechanical transmission and control, Programmable controller	Electrical control and PLC	Integrate course content, in favor of project-based teaching
4	Application examples analyzed in “Hydraulic and pneumatic” course, and “Electrical control and PLC” course	Railway rolling stock manufacture and maintenance devices	Related examples of the course is integrated as the vehicle application examples

3) *Practical integration of the course:* The engineering itself means practice, and the engineering education means practical education, Thus, to emphasis on practice is to make students have the experience of solve practical engineering problems as much as possible, and participate in practical activities, and ensure the quality of practical courses.

The “Excellence Plan” divides the talent cultivation into two phases, namely learning in school phase and learning in enterprise phase. As shown in Table 3, it is the study content

in enterprise training phase of the Vehicle Engineering major, and the time of the enterprise training phase is a total of 39 weeks. During the study and practice of the enterprise training phase, it is emphasis on cultivating the good professional quality, innovative thinking and strong engineering practical ability of students, so as to make students have good engineering research ability, engineering innovation and engineering comprehensive ability, and realize the organic integration of the students’ cultivation, employment and enterprise human resources selection.

TABLE III. RAINING PLAN IN THE ENTERPRISE LEARNING PHASE

NO	Course Name	Credit	Class hours (hours/ weeks)	Required/Elective course	Term
1	Vehicle Engineering Introduction	2	32 Class hours	Required	2
2	Metalworking Practice I /II	3/3	3/3 weeks	Required	2/3
3	Locomotive & Rolling Stock Cognition Practice	1	1 week	Required	6
4	Manufacture, maintenance and operation practice of freight cars	5	5 weeks	Required	7
5	Manufacture, maintenance and operation practice of railway passenger cars	5	5 weeks	Required	7
6	Electric locomotive production practice	2	2 weeks	Required	7
7	Vehicle operations	2	32 Class hours	Required	7
8	Vehicle manufacture and maintenance process design	2	32 Class hours	Required	7
9	Graduation practice, design		16 weeks	Required	8

All in all, through the course integration and reconstruction, the relationship and orientation of all kinds courses in the course system have been further rationalized, the setting of the engineering practical courses and the comprehension and application of the courses have been strengthened, and modern engineering requirements and standard has been used to cultivate vehicle engineering applied innovative talents.

IV. TEACHING METHODS WHICH COMPLIED WITH ENGINEERING ABILITY CULTIVATION REGULARITY

In the teaching method reform, the “Excellence Plan” focuses on the implementation of the learning method which compiled with the engineering ability cultivation regularity. In accordance with the “Excellence Plan”, the teaching content should be organized according to the engineering problems, engineering cases and engineering projects. And the problem-based inquiry learning method, the case-based discussion study method and the project-based participatory

learning method and other kinds of research learning methods should be put forth effort implemented, the cultivation of students’ innovative consciousness and innovative spirit should be emphases on and the training of the students’ innovation ability should be strengthened, and the undergraduate should be required to finish graduation design to improve students’ engineering practical ability, engineering design ability and engineering innovation ability [8-9].

As shown in Figure 4, it is the content of the course “Electrical Control and PLC” which integrated with engineering cases and engineering projects, it contains the contents of engineering cases introduction, relay-contact control system, programmable control system and engineering case analysis and other modules, and can be extended to course design and graduation design according to the engineering practice. Furthermore, different teaching methods are used according to the teaching content and different characteristics of each module.

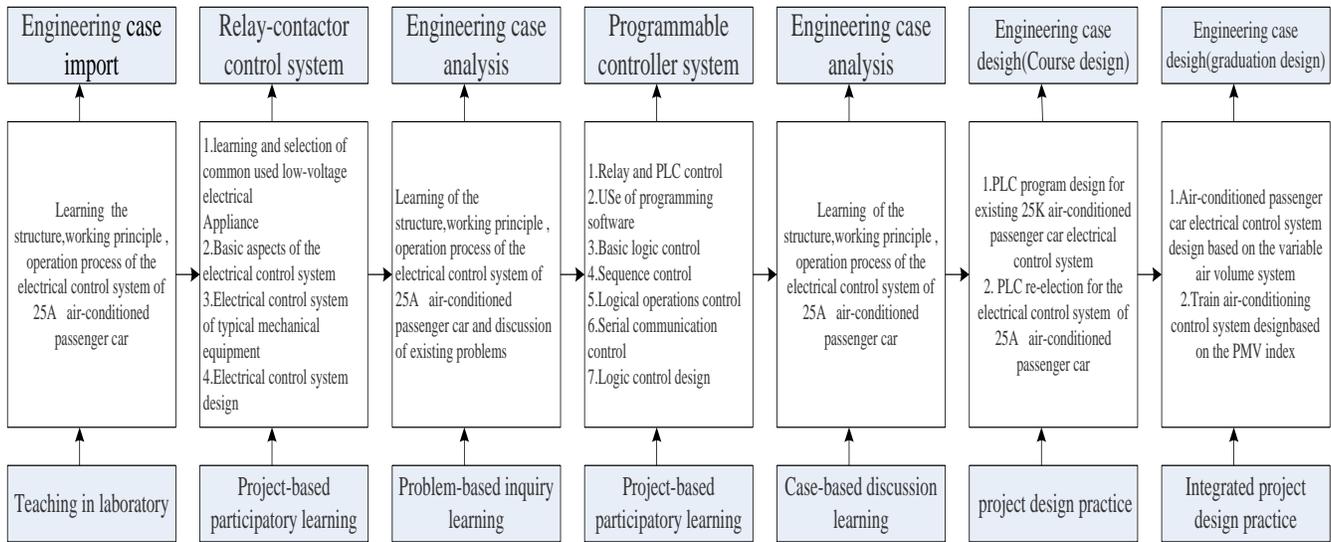


Figure 4. The course structure and teaching methods of "Electrical Control and PLC" course

V. DIVERSIFIED LEARNING EVALUATION

The evaluation mechanism has a directly guidance function for the learning of student, and diversified training objective can be achieved through diversified (knowledge and ability) evaluation items. Guided by the ability cultivation, and according to the characteristics of different courses and different teaching segments, written examination, defense, course paper, field defense, and integrated evaluation and other diversified learning evaluation methods can be used to eliminate the disadvantages of the traditional test such as emphasized the knowledge and result and overlooked the ability and process. And through the guide of examination, it will promote the change of the teaching methods and learning methods, and student's poor rote-learning method can be transferred to learning with a lively mind, and the ability of student will be strengthened [8-9].

As shown in Table 4, it is the evaluation content and standard of the "Electrical Control and PLC" course. It can be seen that different teaching methods are used according to the different teaching content and characteristics of each module, and different evaluation content and standard are used correspondingly.

TABLE IV. THE EVALUATION STANDARDS OF THE "ELECTRICAL CONTROL AND PLC" COURSE

Evaluation subjects	Evaluation Standards	Score
Performance of class discussion	Attendance rate, 20% Well prepared, 20% Well supported and evidenced, argument logic is clear, expression is clear and accurate, 30% Not only using the information, but also have their own independent thinking, 30%;	20%

Written report of the first phase (Engineering cases analysis 1)	Correct format (have parts as introduction, body of the report, conclusion and references), 10% Terminology is standard, formal and smooth, 10%	15%
Written report of the first phase (engineering cases analysis 1)	Well supported and evidenced, argument logic is clear, content is substantive (with citation and examples), 30% Can reflect the process of participation in collective cooperation, 20% Be rich in content, and showing understanding to the history, current status, and domestic and foreign social environment, 30%	15%
Design Plan 1 (Relay control system)	In line with the requirements of the mission statement, 60%; The design theme is distinctive and innovative 20%;	20%
Design Plan 2 (PLC control system)	The plot is clear and beautiful 10%; Have clear improvement process 10%;	20%
Defence 1 (Relay control system)	Proper time control (no overtime and no less much) 10% The key point is focused, content is clear, detailed proper, 30%	10%
Defence 2 (PLC control system)	Project management is organized, 30% Expressed clearly and confidence, 10% The department is proper, 10% Questions be answered rapid and to the point, 10%	10%

VI. CONCLUSION

The "Excellence Plan" is an education teaching reform engineering, and has no ready education mode and mature experience for reference. According to the demand for applied innovative talents of the railway industry and enterprises, and based on the railway specialized characteristics advantage and the applied innovative talents cultivation orientation of the East China Jiaotong University, and in accordance with the system engineering thought as "setting training objectives, setting up training standard,

building course system, reforming teaching methods and perfecting security system”, a new integrated teaching system was built. This integrated teaching system was composed by the integration of the training objectives, cultivation conception and course system, the integration of the course system, teaching methods, learning methods, evaluation methods and continuous improvement and the integration of knowledge, ability and quality cultivation. Through teaching practice, this teaching system has achieved significant effect.

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