

# Construction of Integration Laboratory System for Control Engineering based on CDIO Model

Chaohai Kang<sup>1</sup>

<sup>1</sup>College of Electrical and Information Engineering,  
Northeast Petroleum University, Daqing, Heilongjiang,  
China

Weijian Ren<sup>1</sup>

<sup>1</sup>College of Electrical and Information Engineering,  
Northeast Petroleum University, Daqing, Heilongjiang,  
China

Fengcai Huo<sup>1</sup>

<sup>1</sup>College of Electrical and Information Engineering,  
Northeast Petroleum University, Daqing, Heilongjiang,  
China

DiYu<sup>1</sup>

<sup>1</sup>College of Electrical and Information Engineering,  
Northeast Petroleum University, Daqing, Heilongjiang,  
China

## Abstract

Based on the “integration” thought and CDIO standard of CDIO education idea, the model of laboratory system for controlling engineering in CDIO mode is studied, and the three “integration features” of the system are analyzed. Taking the construction of control engineering laboratory as an example, the overall structure and concrete connotation of the system are clarified. Three key segments of establishing laboratory system are proposed and analyzed, namely, strengthening the construction of the experimental teaching staff, innovating in the experiment management system and optimizing the approach of laboratory construction.

**Keywords:** CDIO; integration; laboratory system; control engineering

## 1. INTRODUCTION

Experimental teaching is an important segment in engineering education, and strengthening laboratory construction is of great significance for enhancing students' practical abilities. At present, there exist three serious shortages of laboratory construction in most colleges and universities in China. Firstly, the investment is not projected reasonably, and not forming a joint force. Secondly, experiment resources are seriously insufficient, especially after the enrollment that the pace of investment in experiment equipments has not kept pace with the scale of expansion. And most of the professional laboratories are in overloaded operation, influencing the life of the equipments severely. Thirdly, the experimental type is monotonous, which is not conducive to the cultivation of the diversified talents. All these disadvantages have resulted in the experimental equipments' oldness,

equipments' overloaded operation, experimental projects' backward settings and experimental teaching's poor effects.

Based on the above reasons, the CDIO teaching mode, born in 1990s and characterized by the binary learning experience which can deepen learning technical basis and practical ability, has gained wide attention in the domestic and foreign engineering education area, and has been employed and innovated in many institutions of higher learning in China. CDIO Engineering Education Model is composed of four segments, including conception, design, implementation and operation. Education concept of CDIO advocates that students learn and acquire engineering capability in an independent, practical way with organic relationships existed between the curriculums<sup>[1-2]</sup>. There are 12 standards in CDIO, among which the third one "integrated curriculum plan" and the seventh one "integrated learning experience" require that laboratory system under the CDIO mode should have the feature of integration<sup>[3]</sup>.

## 2. Laboratory system model

Firstly, laboratory series is constructed in accordance with the integration of experimental curriculum system. With the project laboratory being the point, unit laboratory being the line, laboratory series being the surface, and laboratory system being the body, the overall laboratory framework is constructed of point, line, surface, body, and this highlights the integrated structure of the laboratory structure and level.

The construction of integrated control engineering laboratory system should combine subject features and professional features. Each lab series has its own characteristics of specialty and discipline, and the relationships between each other reflect the relevance between the majors of the control engineering. Project laboratory is the most basic element in the laboratory system, and there are hierarchy, correlation, specific

experiment contents and clear training objectives between project laboratories. These contents and objectives have clear and associated complementarity division, which form the unit laboratory together. Similarly, each unit laboratory is established according to the theory curriculum or theory curriculum group, which can reflect the substantial requirements of a certain curriculum system. Thus, unit laboratories constitute an organic laboratory series together that reflects the content of each professional. It needs to explain that the curriculum intersection between the professionals of control engineering determines the cross fusion of every laboratory series, and these crossed laboratory series constitute the organic whole of control engineering laboratory.

According to the training objectives of automatic control specialties and requirements of the CDIO syllabus, combining with the training schemes of similar colleges and universities at home and abroad, researching the requirements and developments of the control science and engineering industry at home, the integration of the theory curriculum system is established and improved. Taken the integration of theory curriculum system as a basic reference, the control basis laboratory series, the control and detection instrumentation laboratory series, the motion control and image processing laboratory series, the process control laboratory series, the embedded systems laboratory series and the integrated innovation laboratory series are formed. Each laboratory series consists of several closely related unit laboratories, and relies on the corresponding theoretical course group and experimental course group. There are strong cross correlations between each laboratory series, for example, several unit laboratories can constitute an innovation lab of rich functions. Thus, the experimental resources are integrated and optimized further, which

improves the efficiency in the use of experimental resources greatly.

Secondly, it is closely around the integration of experimental curriculum system, aiming at strengthening the students' abilities of modern control engineers, such as practice ability, knowledge application ability, innovation ability, team cooperation ability and certain social ability. Then the laboratory stereo platform with capability gradient is built, which promotes the integration of knowledge and ability.

From the laboratory level, there form six levels of the laboratories, including cognition type, application type, operation type, design type, synthesis type and innovation type<sup>[4]</sup>, as shown in Figure 1. The cognition typed laboratory mainly provides the perceptual cognition of the automation industry knowledge and the basic theory knowledge, deepening students' understanding of the automation industry and the theoretical knowledge. The application typed laboratory emphasizes the ability of applying the theoretical knowledge, requiring students to be able to analyze and solve the problems that are simple and relatively close to engineering practice. Operation type focuses on the cultivation of students' manipulative ability. Design typed and synthesis typed laboratories emphasize on the abilities of knowledge application, theory combining with practice and team cooperation, which highlights the integration of knowledge and ability, the integration of theory and practice. Innovation typed laboratory tries to cultivate students' comprehensive ability and highlight the dominant position of the students, such as the innovation design laboratory of embedded control and detection system, specialized comprehensive laboratory of production process automation, etc.

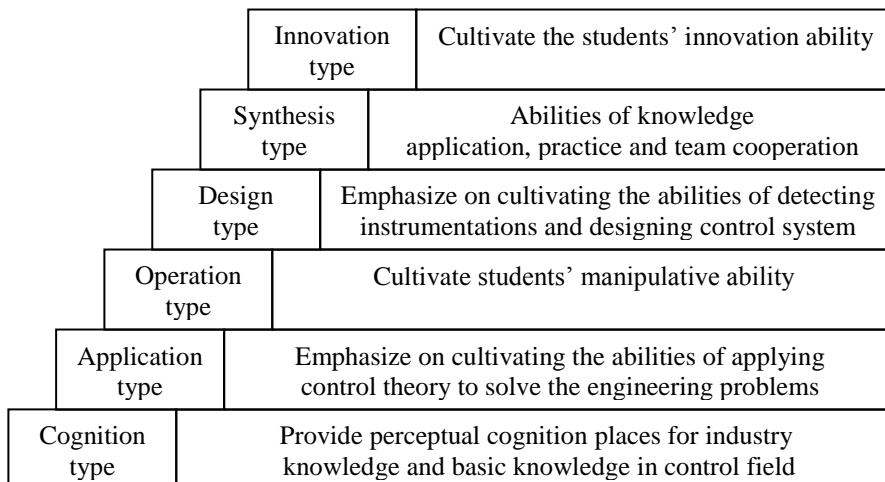


Fig. 1: Laboratory gradient distinguishing diagram

CDIO advocates the integration of the curriculum plan, and positions the cultivation target as the integration of knowledge and ability. Therefore, the laboratory

construction is based on the integration of the experimental curriculum system, by the integration construction of experimental project and laboratory, the integration of

knowledge and ability is realized. According to the training objectives of the experiment course, the project laboratory setting improves, perfects, and updates the existing laboratory; each project laboratory has explicit ability training objectives and implementation method. For each certain project in the laboratory, its knowledge training objectives and ability training objectives are definite, and the setting of the objectives needs to be able to reflect the idea of CDIO completely. At last, the sum of the each project laboratory's target can reach the total target of the unit laboratories, and the sum of unit laboratories' cultivation targets reach the total target of the laboratory series.

Thirdly, according to the general requirements of CDIO on the cultivation of knowledge and ability, each experiment project is designed in detail. From the aspects of training objective, training method, experiment content, ability cultivation measures, and assessment methods, etc., the contents of the experimental projects are optimized, which promotes the integration of "doing" and "learning" for students.

In order to realize the integration of "doing" and "learning" in experiment teaching and learning, the contents of the experiment projects are designed as follows: the source of experiment project was combined with the reality of the laboratory and production practice application as much as possible. The contents of the experiment as a whole contain three aspects, namely, the preparation of the experiment, the introduction of the case and the experimental guidance. The preparation of the experiment mainly provides the knowledge application background of the experiment, expands the students' knowledge horizon, and increases the practical knowledge, etc. This part can include appropriate practice, investigation, workshop video to enhance students' practical knowledge; introducing the laboratory project related books, materials and production backgrounds, etc. The introduction of the case provides reference and help for students' independent experiments, and can embody and simplify complicated principles, backgrounds, operations, and so on, so as to help the students get into the role soon. The experimental guidance can lead students to study and conceive the experimental objects initiatively from the aspects of scheme selection and scheme design, and so on. After the detailed design, the experimental project has the characteristics of specific experiment content and strong guidance, and guarantees that students have the ability to achieve the transition from "passive infusing" to "autonomous practice", which promotes the effective combination of "doing" and "learning".

### **3. Key segment of integrated laboratory system construction**

Firstly, the construction of teaching staff is the most important aspect of laboratory software construction in

CDIO mode. It strengthens the construction of the double type experimental teaching staff from the aspects of teachers' cultivation, young teachers' practice, cooperation of school and enterprise, and so on, promoting teachers to reform and explore the CDIO teaching method consciously at the same time.

The ninth standard and tenth standard of CDIO demand the improving the teachers' abilities of engineering practice and CDIO teaching, and the cultivation of double type teachers is the important basis of practicing the CDIO teaching mode. Firstly, by the actions of encouraging teachers to establish enterprises, supporting horizontal scientific research, strengthening the consciousness of serving the enterprises, etc., the teachers' practical abilities are promoted to enhance. Secondly, strengthen young teachers' exercise of working part-time in enterprises. Cooperate with the enterprises in the surrounding areas, establishing more than ten outstanding internship bases, and providing young teachers with opportunities of enterprises training for at least one year. Finally, strengthen cooperation with enterprises. On the one hand, bring in directly the senior engineers in the enterprises as the part-time experimental teachers. On the other hand, invite enterprise personnel with rich experience to participate in the design of the experiment projects. In short, for the planning, design and implementation of the laboratory construction, the construction of experimental teaching staff is the main body, that experimental teachers should be made to deeper understand and study the basic ideas of CDIO. Promote teachers to implement consciously the practice teaching principles in the laboratory construction that students are the main body, teachers are the guidance, knowledge and ability are both important; and implement the experimental teaching standards of CDIO indeed.

Secondly, in order to ensure the implementation and effect of the CDIO concept, we must innovate in the practice teaching management mode. The reform of laboratory management system is the key segment of laboratory construction. We strive to develop open laboratories, innovative laboratories and independent laboratories to expand the experimental teaching mode, improve the utilization of experimental resources, and increase students' initiative learning experience.

Open laboratory can solve many problems such as many people, large quantity and low utilization of resource in the laboratories, and further meet the high requirements of comprehensive and design experiments on the experimental resources. The innovation laboratory is the highly independent laboratory, and proceeding with the control engineering innovation design and innovative project research in the form that students are the main body and teachers are the guidance. Through the construction of innovation laboratory, in recent years, the students who are in control class in our school have obtained one national first prize and many second prizes in the National Undergraduate Electronic Design Contest, China University

of bio Networking Innovation and entrepreneurship contest, and other competitions. The autonomous laboratory is the experimental teaching of interest groups, organized autonomously and proceeded spontaneously by the students. The academy provides the students with places, former students' design products and results of the experimental projects, etc., and the students proceed with the autonomous experiments, designs and research according to their own ideas. In the initial stage of the autonomous laboratory, it's required to equip support tutors and organize interest groups, which will be displayed, communicated, competed, compared inside the academy, influencing and bringing along more students to participate autonomously.

Thirdly, under the mode of CDIO the hardware construction of the laboratory needs to consider factors such as the capital investment, integration of resources, teaching requirements, we combine with the practical condition and propose the construction idea of dual platform, multi ways, optimization and integration

Encourage the teaching research projects, scientific research projects, students' innovation projects, and independent practical projects to combine with the laboratories, and enrich the way of laboratory construction. Use the policy to greatly encourage teachers to work on teaching research and scientific research at the same time of teaching, and provide special offices and experimental places for them. Develop the cooperation of school and enterprise, thus it is achieved that the enterprise and school construct the laboratory together. For the new established undergraduate of application type, it ought to be combined with its professional characteristics, the advantages of the subjects, and the development of the local economy, then the breakthrough point in which to combine with the local enterprises is found, which realizes the cooperation of the school and the enterprise with mutual winning and benefits. Besides, the renewal, transformation and restructuring based on the existing laboratory resources are the important ways to meet the experimental teaching in the CDIO mode.

#### 4. Conclusions

Constructing the integration of control engineering laboratory system in the CDIO mode is the important part

of the national characteristic specialty construction of automation in the school. After the laboratory construction in recent years, the automation experiment center in the school has preliminarily had the hardware facilities and software conditions which can satisfy the CDIO teaching mode basically. In the last few years, it is seen from the feedback information of the graduates' employment and the results of the students' practical innovation competitions that the effect of experiment teaching and the effect of comprehensive teaching are greatly improved.

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