PRACTICE OF GRADUATION DESIGN BY APPLICATION OF CDIO CONCEPT

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ABSTRACT：Illustrated by the example of process equipment and control engineering major, this article discussed how to improve the students' comprehensive ability under the guidance of CDIO engineering educational concept during phase of graduation design. In the article, the author described how to integrate concepts such as the large-scale engineering, cultivation of comprehensive ability and close contact with industrial actual practices into each link of graduation design during the research and development of full series and all categories of "corrugated tube type half volume type heat exchanger" through the cooperation between college and enterprise. Specific practices included how to integrate the research and development of the other engineering projects into graduation design; how to combine the comprehensive professional curriculum design with the graduation design, and how to embed more tasks of practical significance into the graduation design. The results of the implementation indicate that the practice of educational reform based on CDIO concept could feasibly ensure the quality of the graduation design.

KEYWORDS: Process Equipment And Control Engineering, CDIO, Continuous Graduation Design, Cooperation Between College And Enterprises, Competencies Of Engineering Practice; Standards: 5,7

1. INTRODUCTION

CDIO engineering education mode is the newest achievement in international engineering education reform proposed by an international research organization constituted of four universities such as Massachusetts Institute of Technology, which has earned widespread acceptance by international engineering educational world. (Tao Yongfang et al.,2006) To understand its profound meaning and apply it to guide our practical work is the bounden duty of teachers in college of engineering. CDIO model has four remarkable characteristics: systematic reform on engineering education; large-scale engineering concept, emphasis on the cultivation of comprehensive quality; close contact with the industry. (Wang Gang,2009) This article focuses on the exploration and the practices in these four aspects.

To apply the CDIO concept in the cultivation plan and the teaching implementation in the engineering colleges, the educators must, to the greatest extent possible, consider the conception, design, implementation and operation of product, process or system to be the environment of engineering education. The most favourable condition for CIDO mode is the involvement of the enterprises. Last year we had cooperated with a company in Qinhuangdao Economic Development Zone on the research & development of full series and all categories of "corrugated tube type half volume type heat exchanger". Many senior students had an unforgettable experience during the graduation project design.

The project cooperated with enterprises on the research & development of full series and all categories of "corrugated tube type half volume type heat exchanger" was the all-round cooperation, which included the heat transfer calculation, process calculation, structure design; strength calculation and medium calculation (containing steam-water heat transfer calculation and water-water heat transfer calculation). Structures involved in the project included vertical and horizontal types, single hole and double hole overlapping types. Equipment involved included more than a dozen of different sizes in volume. The work of full sets of corresponding drawings was completed and the corresponding supporting soft wares were also developed. The project was, to some extent, a small-scale systematic engineering project.

Students were divided into groups to facilitate field research and discussion, and every group had 3 students. Each student was required to have his own topic. They had participated in the entire engineering process: from the heat transfer and process calculation to the structure design and the strength calculation; and from proposing manufacturing assessment and maintenance requirements to draw a set of equipment graph. The whole process of design should follow GB150, GB151 and relevant national standards and the other industrial standards.

2. GRADUATION DESIGN REFORM OF THE PROCESS EQUIPMENT AND CONTROL ENGINEERING MAJOR BY APPLICATION OF THE CDIO CONCEPT

2.1 The Concept of Systematic Engineering Educational Reform Throughout The Whole Process of Graduation Design

CDIO education mode is a systematic reform of engineering education. Engineering education changes from “science paradigm” to “engineering paradigm”, that is to say, engineering practice faced with the era of globalization should combine science and technology as well as technology and non- technology together, and emphasize practice, comprehensiveness and innovation of the engineering education. To carry out that plan, we should not follow the old way. Essential changes must be made in the topic selection and teaching requirements. We made several key substitutions, using engineering criterion to substitute the teaching standard. We adopted principles of "graduation design topic closely related to the engineering project, the teaching requirements closely related to engineering criterion, design method closely related to engineering training, design environment closely related to the engineering site”. The topics came from the engineering practices and the whole process of design followed the national standards and other industrial standards. We carried out an all-round reform in the aspects of curriculum system, teaching content, teaching method and approach, and enabled the engineering education return to engineering practices.

2.2 Large-scale Engineering Concept As The Main Line In The Task Of Graduation Design, Integrating Every Aspects Of The Profession As Basis

CDIO model interpret engineering from a more broad perspective, in which engineering is no longer limited to technology. Engineering is combined with many factors such as social development, market rules and management mode. To cultivate engineering talents from a macro and systematic perspective, the teachers should make training objective, curriculum and teaching mode under the guidance of large-scale engineering concept. The large-scale engineering idea turns specialist educational mode to the integration of "specialist and generalist" mode. Therefore, the task of graduation project adopted the large-scale

engineering concept as the main line, and discipline crossing and integrating every aspects of the profession as basis. That would enable students to learn the engineering in a way that is active, practical, and multi-course organically related. The whole teaching process should not be confined to the study of the professional knowledge and technology.

In the reform of the graduation design, we adopted completely the "design institute mode "，which was practical in enterprises. The mode concentrates on the following area: taking the actual project as the background, following the actual project requirement, and finding out the demand of social development based on research in the market; solving technological problems by visiting the site to study the latest technology trend; learning actual structure design by visiting the manufactory. Tackle all the problems following the national and industrial standard while adopting the typical industrial pattern. From feasibility study to implementation of the project, the design concept of "large-scale engineering " was fully embodied.

Students in their fourth year of college have the task of the detection and control design and piping design, therefore it is difficult to complete all of these tasks during the graduation project. During the conceiving and planning of this teaching reform we had considered the heavy workload and busy schedule of students and therefore we combined course design and graduation design together: i.e. “comprehensive professional courses design” in the seventh semester and “the content of graduation design “in the eighth semester were rearranged and integrated. After the recombination, this continuous teaching approach made each part of the design process organically related and integrated. Encircling the main topic of curriculum design, detection design, control design and piping design topics could be finished. That would ensure that the students could finish the whole process of design around one topic, and complete the whole set of the equipment design. Different stages of content had a focus, but they were internally and progressively related.

The fourth year of college is a chaotic year. Various interferences have a big impact on the graduation design. Some of the students spent quite a lot of time on the graduate entrance examination or searching for a job. Graduation design is not paid enough attention. On account of this, the project research, scheme design and related experiments could be done during the spare time such as morning and evening break, weekends and holidays. Some of the topics had been delivered to the students a semester in advance. In that way, the impact of these interferences had been alleviated. That could present active learning opportunities and conditions, and then the quality of graduation design was improved.

2.3 Cultivation Of Comprehensive Quality As The Core Task In The Implementation Of The Graduation Design

CDIO model can be described to be an engineering educational approach that set project design as guidance, engineering competence cultivation as the main objective. Under this training approach, educators can combine the whole curriculum together organically and systematically throughout project design. All the content that needs to be learn and master are designed around the core project design and is implemented step by step.
The training objective of CDIO mode is comprehensive, including not only the professional technological knowledge, but also the development of various aspects of the comprehensive ability. We integrated the training objective into the whole design process; each competency requirement was implemented in specific design of each link based on the requirement of four CDIO syllabus competences. For example some small research and development

program were implanted into the whole graduation design. Students had been taught in accordance with their aptitude to cultivate their individual ability of doing experiment and analysing and solving problems. These kinds of topics could help the students to cultivate individuality and comprehensive ability. The cultivation of individuality would support and guide the students to find their interests and hobbies. This actual problem-solving process is also a teaching process that is operating-friendly and has explicit objective. Common constraints have been reduced，and more individual space has been expanded. The progress of all the students were not under the same standard and model，rather, their comprehensive ability should be improved properly and constantly.

In the process of performing the "design institute model ", students solving the problems in the real sense had improved their engineering thinking. To operate large-scaled, modernized and complicated process equipment also required the students to be good at engineering thinking. The theoretical teaching in our classroom is often accustomed to scientific thinking. In general, the scientific thinking focuses on analysis and handles all kinds of problem in decomposition and refinement, and then studies them respectively; engineering thinking, however, focuses on synthesis, after going through the process of decomposing and refining of various questions , recombine and study them according to the objective requirements，so that the overall understanding of the questions are achieved. Practically, engineering problem is perplexing, and many factors often intertwined. Students must take many relative factors under comprehensive consideration. So it is very necessary for students to use engineering thinking. (Zhu Gaofeng, 2005) (Tu Shandong,2007)

Team spirit could also be developed in this design mode. This cooperation, involving peer cooperation at school, cooperation with construction unit outside school, cooperation with the technical personnel of the equipment helped students understand the importance of the inter connections of different professions and the strength of cooperation.

2.4 Close Contact With The Industry As The Means And Approach Throughout The Progress Of Graduation Design

CDIO educational model is directly related to the industrial demand. In the process of the design, many kinds of practical problems occurred. We took measures such as comparing our designs with engineering standard examples, hiring senior engineer to give lectures and to have discussions with us. The problems could be solved by the discussion and analysis by everyone in the team. Many categories of drawings, data, pictures and videos were borrowed and researched. The team made several times' visit to the pressure vessel-manufacturing factory, corrugated tube manufacturing plant and other enterprises. Those made the students explore the ways to solve the practical problem in the actual engineering site. The students researched and studied many times on site to make sure they understand the corresponding questions such as welding structure of the corrugated tube and the tubeplate and the connecting structure of the corrugated tube and the baffle. These practices indirectly enhanced students' ability of interpersonal communication and the aptitude of conception, designing, implementation; and improved their learning interest and motivation. The project design was the essence of engineering practice，and the implementation process should be closely linked to actuality. This approach had completely changed the teaching mode, which focuses on teaching only. The knowledge of students is not gained by teaching，but by learning. This teaching approach reform fully embodied the "student-centered, hands-on learning-centered, studying effect-centered" teaching concept.

2.5 Evaluate And Assess Students Based On Initiative Learning Effect And Comprehensive Learning Effect

The content of the graduation design was fundamentally different from the previous ones, so are the assessment mode and process. The assessment included professional knowledge and skills, working initiative, cooperation, innovation, responsibility, engineering consciousness, practical ability and comprehensive level of the achievement. In this design, the students were guided to deal with the practical topics in which they must find and solve problems before they had fully grasped the professional design knowledge. The corresponding assessment pattern and content are diversified. The assessment ,which embodies the entire-ranged, dynamic and comprehensive characteristics，accompanied the whole design process. The assessment included evaluating students' ability to identify problems, to ask questions, to simplify the problem and eventually to solve the problem, examining their initiative learning, hands-on learning practice, the effect of a comprehensive study, and differences and distances between the requirements of the practical engineering application and the students' final design product. Finally, comprehensive evaluation results are given according to their submitted works, oral defence as well as the effect of practical study.

3. ACHIEVEMENT

It took more than a year to complete this task, which included the preparation research and nearly two semesters of design practice. Teachers, graduate students and undergraduate students all took part in this work. A full set of drawings, data and materials had been evaluated and accepted by both the professional design organization and enterprises and had met the requirements of the enterprises. The design calculation and strength assessment were completed respectively in accordance with the national standard and industrial standard by manual calculation and SW6 software calculation of national pressure vessel calculating center. Students obtained both professional skills and software application competence.

The achievement of the teaching reform was significant in every aspect. This was the first time that we were using CDIO module to organize teaching practice. It was a trial that put CDIO syllabus and standards into practice consciously, naturally and initiatively.

3.1 Students' Engineering Competencies Were Enhanced Significantly In The Process Of Project Implementation

According to the CDIO syllabus, the engineering education is to educate the engineers and the core ability is the engineering ability. On retrospect, the essence of CDIO model train engineering students with engineering approach which can be described as project design-oriented, to enable students to have contact with the real engineering practice in the educational process. A pragmatic attitude was fostered and therefore, a genuine harvest was achieved. After completion of the project, acceptance check has been implemented by the enterprise and three students were hired. That "an education is to create value from the students" was indeed what we had experienced. Engineering capabilities were improved in the following aspects: the design process enabled the students understand explicitly the national standards and industrial standards. From the level of having heard of and witnessed to skilfully apply the standard when dealing with practical engineering problem, this was a qualitative leap. In the process of design they understood the profound meaning of the sentence that "use the standard to ensure the safety of the equipment, and use the standard

to ensure the safety of user and designers of the equipment”，which was said by the experienced engineering technical personnel. Students’ behaviour in the process of design also enabled the engineering consciousness remain in their mind deeply, which would be a lifelong benefit in their future work.

3.2 Project Implementation Process Cultivated Students’ Spirit of Collaboration And Their Sense Of Responsibility.

This experience allowed student to play a role of prospective engineer in the approximate social environment under the guidance of CDIO system, real topics enabled the students to undergo training in the whole process of project conceiving, designing and implementing with sense of social responsibility. Students also went through the repeating process of finding out their loopholes and reconsidering the solutions for quite a lot of times. This repeating process had deepened and improved their understandings. The consensus of the students was that they should not be satisfied with simply complete the task. In order to have better achievement, they would like to explore further. The discussion, mutual questioning, cooperation would lead to new discoveries and therefore, a new harvest.

3.3 Students’ Motivation For Study Was Improved In The Process Of Project Implementation

CDIO standard emphasizes learning initiative. This learning module is very attractive to the student. With interests and desire to learn initiatively, the students enjoyed the feelings of “experiencing the environment”，and they achieved the sense of responsibility and achievement in the process of project. Working with the real topic made the students understood the profession more deeply and comprehensively. As they say, they had understood what their profession was and what they would do in the future，and therefore loved the profession and were more passionate about it. The process to solve the problem also enhanced their ability and confidence, and the advantages were reflected in the subsequent job hunting. Just as Confucius says: “who likes is better than one knows, who enjoys is better than who likes.” Enable the students willing to learn is our biggest motivation to work.

3.4 Teachers’ Competencies Were Improved In The Process Of Project Implementation

CDIO standards emphasize the improvement of teachers’ competencies. Only the good researchers could be the qualified teachers, and only who themselves engage in the study have the knowledge to teach the students. Practical teaching is more comprehensive and complex than theoretical teaching. It is easy to teach and solve theoretical problems on the blackboard，but when dealing with some specific problems in practice it will probably be quite difficult. A problem may not be perfectly solved until after more than 10 times of review over the drawings. Although the guiding teachers have engaged in the professional work since twenty or thirty years ago, who also have certain engineering experience with assessment qualifications in this area， the teachers still reaped new awards during in-depth study and discussion of some issues. As the saying goes “teaching benefits teachers as well as students, a worthwhile trip”. In addition, the teachers would make their instruction more vividly and fluently and made the knowledge taught professionally by speaking of their first-hand experience. On the other hand, this unforgettable experience had also given the teachers a profound experience of the extent and depth of requirement of the CDIO and helped the teachers identified explicitly the objectives and directions in the future.

4 CONCLUSION

In June 2010, the Ministry of Education initiated “Plan of Cultivating Excellent Engineers”. We understand that there are three main features: the first is that the industry enterprises participate in the training process; the second is the school cultivate the engineering talents in accordance with the general standards and industrial standards of talents training; the third is to strengthen the students engineering ability and creative ability. Now reflecting on the work we have done, we have found that every step seems to be on the track of the CDIO mode. Our work is in consistency with the direction of CDIO concept.

In this teaching reform, we have achieved unexpected result, which have greatly exceeded our expectations. And this teaching mode is not unchangeable; it should be accommodated in accordance with the demand of the society and it should cater for the orientation and characteristics of our college. We will implement CDIO standards and requirements omni-directionally in the whole training plan of our major. We will reform and explore continuously so that the quality of our work will be improved constantly.

CDIO mode should be regarded as the guidance for our practical work. It is highly necessary to participate in the engineering project, collect engineering data, establish the concept of large-scale engineering project, make close contact with industry, highlight engineering characteristics, and cultivate engineering talents of comprehensive ability. These are the eternal missions of engineering colleges.

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