Implementation Strategies of CDIO for Massive Scale Education

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ABSTRACT

China's local undergraduate universities take the great responsibility of cultivating engineering talents on a massive scale. They are confronted with many similar difficulties in their development process, namely the massive scale of talent cultivation, the lack of resources and the buckets effect of teachers' qualities, etc. Yanshan University is one of the pioneering universities to integrate CDIO into education practice in China. Based on years of practice, Yanshan University has developed a methodological framework to combine the latest educational trends with the real situations: integrate the current education resources, popularize the experience gained at one school to the whole university, and gradually carry out the reform in a systematic way. The guarantee mechanism of the whole process is as follows: first, we make a top-level design and then enforce it from the university to departments with support from the university and school leadership. Second, we emphasize the construction of mechanism and atmosphere to ensure the reform implementation. Summarizing and analyzing the experience and process of CDIO engineering education on a massive scale, we can further clarify our own ideas to promote teaching reform and also provide a reference for the same type of institutions of higher learning.

KEYWORDS

Massive scale cultivation, Project-based teaching, Top-level design, Standards:3,5,9,10,12

Yanshan University is one of the first leading universities to integrate CDIO in the engineering education at university level; it was also accredited by the Ministry of Education to participate in the CDIO Engineering Education Reform Program to be the leading member in mechanical team. In 2013, Yanshan University joined the Worldwide CDIO Initiative and became an important member in the Asian region. In 2016, Yanshan University will host the CDIO Asian Regional Meeting. As a local university known for the engineering education, Yanshan University has the typical difficulties similar in local colleges and universities. They are obliged to train the engineering talents on a massive scale; meanwhile, they are also confined by the realities of limited resources in software and hardware, faculty knowledge with more on theories than practice, relatively lagging educational ideologies, and so on. Yanshan University is trying to explore a pragmatic path to combine the latest educational trends with our own situations from the perspective of methodology, which is also a major theme of our educational teaching research in recent years.

1. Difficulties and Problems of Massive Scale Cultivation for Engineering Talents in Local Undergraduate Colleges and Universities

At present, the engineering education in Chinese higher learning institutions has reached more than 1/3 of the world higher education, and local colleges and universities undertake 90% of engineering teaching in China. With the application transformation in Chinese higher education, massive-scale cultivation will be a long-term ordinary phenomenon in Chinese local universities. Yanshan University is one of the forerunners to introduce CDIO in engineering education reform; the difficulties confronted with Yanshan University are very typical in Chinese colleges and universities.

1.1 Large-scale Cultivation Leads to School Resources Shortage and Restricts the Rapid Development of CDIO Education Reform.

Many years of teaching research and practice indicate that students in the spoon-feeding teaching mode are often poor in comprehensive innovation abilities with the imbalance between theory and practice. They are incapable of solving practical engineering problems and cannot meet the needs of industry. This problem can be solved effectively by increasing the proportion of practice and stressing the CDIO engineering educational concept of “learning by doing”. However, the implementation of reform is often trapped due to the large scale and limited education resources. Especially in the process from pilot reform to massive scale cultivation, the conflict is very severe between education resources and the needs of students and teachers. The rapid advance of the engineering education reform will be hindered by the lack of laboratory space, equipment, supplies and the cost of experimental materials.

1.2. Lagging Educational Ideologies of the Faculty Prevents the Further improvement of Overall Implementation.

Educational philosophy of “outcome-based, student-centered and teacher-led” is of the same nature with the idea of CDIO engineering education. Therefore, the quantity and quality of the faculty is key to success for CDIO engineering education. The current faculty recruiting system emphasizes theory and academic level and causes the insufficiency of teachers with rich practical experience of industry. Most teachers lack practical engineering training and their engineering qualities are short of real engineering practice. Thus, on the one hand, when they teach theory courses, they cannot combine theory and practice and cause the boring classroom atmosphere with low enthusiasm of students to participate in class. On the other hand, when they guide the students to engineering practice, they can't present students a "demonstration project" or "project guide" to motivate students’ enthusiasm in active practice. Such loop will obviously have can negative consequences as the Matthew effect.

1.3. Rigid Disciplinary Setting and Insufficient Management System and Mechanism

The reform of Chinese higher education is still in the phase of climbing. It is still in the exploration period for the management structure, method and mode. The current administration structures determine the problems of rigid disciplinary setting and inelastic time planning in Chinese institutions of higher learning. It is still very common to value much more on scientific research than teaching due to the current incentive mechanism. The existing performance evaluation mechanism in the

colleges and universities has very important guiding role for the distribution of education resources. The above problems are relatively more prominent in local colleges and universities. Teachers are often busy with scientific research project application, research paper writing and publication because these activities are directly related to their own interests. They can't have equal input on teaching to educate people with great concentration. Each teaching unit even cannot mobilize teaching resources to fulfill their fundamental task of serving students' growth. In a deep sense, the main factors restricting teachers' input on teaching are the systems of human resources, performance evaluation and professional title appraisal. The disadvantages of the above systems block the lifting of their worries. Faced with large-scale cultivation, the extent of teachers' devotion will be the critical factor to determine the quality of engineering talent cultivation.

2. CDIO Engineering Education and Teaching Practice of the Yanshan University on a Massive Scale

Historical experience shows that problems and contradictions are more likely to appear in the development period. The key is still the reform determination and rational strategy. To make the best possible use of talents and materials of the existing resources, we adopt the following strategies: integrate the current education resources, popularize the experience gained at one college to the whole university, and gradually carry out the reform in a systematic way.

The Mechanical Engineering School became the pilot school in Yanshan University and introduced the CDIO engineering education concept in 2007. The school then carried out the "project-based" teaching reform based on CDIO concept.

The reform covered all courses and teaching procedures and involved all teachers and undergraduate students of the school. The school strictly followed the CDIO syllabus and standards, set up the project-based course teaching system and developed the design-oriented training program with engineering ability training at the center. The reform constructed a Graded Teaching Mode led by three-level projects. This mode combined a variety of teaching methods and content including class lecturing, experimental teaching, research discussion, project implementation, product contest and other forms of teaching activities. It provided students a full range of ability training including theoretical knowledge, practice application, integrated refining, statement summarizing, etc. The reform established the curriculum assessment mechanism with attention to the whole process monitoring to cultivate comprehensive abilities. The assessment covered common performance, practical operation, project research, knowledge application and team presentation, etc. The mechanism ensured all students to participate in the teaching activities and improved the training quality.

Up to now, six different years of student have been trained under the project-based teaching mode. The school has about 3,000 graduates. Those graduates got better employment because of their good knowledge structure and strong abilities of

comprehension, innovation and practice. Many employers offered graduates jobs long before the official campus job fair. A large number of graduates were employed by the well-known domestic companies and enterprises. The teaching reform acquired great achievements.

After the initial success in the School of Mechanical Engineering, the university began to introduce the reform to the other schools gradually. In 2013, the university organized the teaching reform project for the single course. The aims of the project are: promote the deep integration of theory and practice teaching; improve the students' interest in learning; enhance students' innovation and practice ability; reconstruct the curriculum system; make a systematic reform on curriculum teaching content, teaching methods, assessment methods and practice teaching. The university promoted the project-based teaching reform based on the experience of the Mechanical Engineering School. The proportion of practice teaching was increased in the majors of liberal arts and sciences. It was required to account for at least 1/3 of the total teaching hours. In order to ensure the reform effect, half of majors were required to participate in the "teaching reform project" including all national and provincial key disciplines.

The university expanded the reform scope after the transition year of 2013. Since 2014, guided by CDIO engineering education idea, the reform on talent cultivation and the construction on curriculum standardization are introduced into nine national or provincial "Comprehensive Reform" disciplines and five "Excellence Engineer" education programs. The cultivation of knowledge, ability and quality is regarded as the three educational goals. Based on market investigation and research, the training objectives are revised. The comprehensive reform on talent training mode is carried out and allocated to every course. The specific requirements are: (1) Establish the project-based teaching system. The third-level project is accompanied with each professional course, and the second-level project is set up with each discipline in the form of student team. (2) Professional basic courses increase the proportion of practice teaching. The elective courses adjust practice teaching hours (project, experiment, discussion, research, speech, reporting, performance and so on). The amount should be no less than 1/3 of the total teaching hours. If all goes well, the reform will benefit about 5,000 students of each year. Large-scale cultivation becomes worthy of the name.

In the summer vacation of 2014, staff and faculty from 14 majors began the investigation for the revision of training plan. They visited graduates' employers and other colleges and universities to collect opinions and suggestions. They reviewed the disciplinary training target and made new positioning for talent cultivation based on market demand, and then re-organized the discipline curriculum system. At the same time, in order to further standardize teaching process, to guide teachers to carry out "student-centered, teacher-led" teaching activities, to improve course teaching quality by integrating knowledge, ability, quality, the university formulated *the Course Teaching Standards of Yanshan University* with reference to the undergraduate teaching evaluation and engineering certification standards from the Ministry of Education. The university's course standards provide concrete content

and standards for curriculum documents, teaching resources, design, procedure and methods, and for practice teaching, curriculum evaluation, teaching feedback, etc. They provide the clear reference for the construction of standardized courses. More than 200 courses from 14 majors will be standardized. In order to guarantee the effect, the university invites experts to evaluate those courses on the basis of *the Course Teaching Standards of Yanshan University.*

3. Strategy of Providing Guarantee Conditions for Massive Scale CDIO Engineering Education Model

3.1 Make a Top-level Design and then Enforce It from University to Departments with Support from the University and School Leadership

The current underdeveloped governance structure of the local universities makes it necessary and important to have top-level design and put leaders in leading role. The "top-level design" contains a number of levels, from the university to the discipline. The corresponding leaders are divided into several levels. The School of Mechanical Engineering started the CDIO pilot program from 2007 and has reached stable achievements and experience. It was proved many times that top-level design and leaders in leading role are critical for the success of massive-scale cultivation.

When promoting the pilot program in Mechanical Engineering School in 2013, the university made a very clear requirement for top-level design: leaders from basic teaching units should take the lead in the project-based curriculum reform. By mobilizing and organizing the leadership, the teaching reform project has a total of 101 courses from 13 schools and it involves a total of 13 school leaders and 38 department deans to take charge of the reform projects, and 2 school leaders and 32 department deans are involved in reform projects. Practice shows a strong demonstration effect for leaders to take the lead in curriculum reform.

Guided by CDIO engineering education idea, the reform on talents cultivation and the construction on curriculum standardization cover 200 courses from 14 disciplines in 2014. Disciplinary chairpersons (most of them are the deans of their departments) have the unshakable responsibilities of revising discipline training plan. The department deans and the school vice deans for teaching affairs are required to host the course standardization. According to top-level design, the university's teaching administration offices are responsible for evaluating the programs. The schools and its departments will evaluate the standardized courses. The basic teaching units set up assessment teams; the team includes the university evaluation experts and the school and department leaders. This will guarantee a clear responsibility division and ensures successful assessment from implementation to verification.

3.2 Emphasize Mechanism and Atmosphere Construction to Ensure Reform Implementation

Any reform cannot have a favourable wind all the way. In addition to meticulous reform scheme and strong reform drive, it is also imperative to have corresponding

supportive policies to power CDIO teaching reform, to mobilize the whole university's teaching resources, to have system construction and educational administration move closer and go around the reform. In order to meet the faculty's needs for personal and professional development and to improve teachers' teaching abilities, the university integrated all offices for teachers' training and founded the Center for Faculty Development at the end of 2012. Since its establishment, the center made great efforts to build a platform for teachers to improve their teaching abilities. Their work includes:

3.2.1 Carry out Special Training for Teaching Reform to Win Support for CDIO Teaching Standards and Ability Syllabus

Based on "outcome-based, student-centered and teacher-led" educational philosophy, the center's establishment is the representative of top-level design for the university's teaching administration. The center takes the responsibility of cultivating high quality engineering talents to cooperate with the teaching reform in 2013 and 2014. It meets the urgent need of teachers for continuing study. The university has organized two rounds of 14 special training and trained more than 4,000 teachers. The training covers leadership, staff and faculty from 14 schools. To further promote experience of the School of Mechanical Engineering to other engineering schools, the university also encourages non-engineering schools to organize and carry out teaching reform with their own characteristics by referring to experience in engineering education mode.

3.2.2 Invite Experts to Lecture and Exchange Teaching Experience to Update Teachers' Teaching Ideology

In order to keep teachers updated with advanced CDIO engineering education philosophy and to improve teachers' teaching skills, the university invited many experts to give lectures. Their lectures involve discipline training standards, curriculum standards and teaching innovation, etc. In 2013 and 2014, to cooperate with the teaching reform, the center organized special training lectures hosted by teachers or departments deans who are in charge of standardized curriculum construction. At the same time, the center invited teachers to host teaching salon with the theme like " role orientation of deans in the reform" to exchange teaching experience.

3.2.3. Organize a Series of Teaching Workshop to Improving Teachers' Teaching Skills

Teaching workshop is the combination of training seminar and counselling. Every workshop is organized with a theme lecturing. The related counselling service will be offered afterwards. Teachers can make appointment through a variety of ways. This kind of training can effectively improve teachers' teaching skills. It helps teachers to comprehend CDIO abilities' requirement for the course and to design their own teaching plan and syllabus.

In addition to these, for top-level design, the university clarifies the following ideas: downsize class capacity, promote small class teaching; encourage and support

teachers' further study, especially the practice learning from the industry; encourage their gaining of practical project experience and updated feedback to the classroom.

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