Transformation of Traditional Engineering Education to CDIO Programs

– Shantou University's Experience

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ABSTRACT

This article summarizes the experiences of implementing the CDIO initiative in the College of Engineering, Shantou University. With a reflection on our practice in the past three years, we have summarized ten important points leading to a successful implementation of the CDIO initiative: 1. Commitments and support from university and faculty leaderships; 2. Comprehensive planning before implementation; 3. Integrated solutions for multi-tasks; 4. Identifying champions and form core team; 5. Involve most faculty; 6. Innovative implementation of the CDIO initiative; 7. Piloting before full implementation; 8. Awareness of the resources constrains; 9. Supports for teaching, learning and leaning assessment and 10. Form coalitions.

Our experience may be more relevant to Chinese universities. However, a comparison with the eight steps of the "number one leadership guru" John Kotter reveals that our ten points largely correlate well with the eight steps. This manifests that the general rules for a successful change may be more general than what we initially thought. Consequently, Shantou University's experience is of value to the CDIO reform of other institutions inside and outside China.

KEYWORDS

Shantou University experiences, CDIO implementation, change management, engineering education

INTRODUCTION

CDIO Initiative has documented an Adoption Process for implementing CDIO in a program or an institution [1]. Chapter 9 of the CDIO book [2] also outlines the ways to adapt the CDIO approach. However, making a change in an organization is so difficult that, according to a Harvard Business Review study, 70 percent of change initiatives were not successful because organizations failed to manage the human reaction to change [3]. It is therefore, important to share and accumulate experiences of managing the changes during implementing the CDIO initiative. The College of Engineering, Shantou University (STU) has started the CDIO educational reform since later 2005. Drastic changes have been introduced into all the five programs offered in the College. The traditional engineering education in China has been profoundly influenced by planned economy, a successful transformation from such an educational model to CDIO demands comprehensive planning and careful implementation. As many universities are adopting CDIO in their engineering educational reform, we believe that it is useful to document the transformation process of the CDIO reform at STU. It would be helpful both in disseminating the CDIO initiative in China and in managing changes in educational institutions in general.

We have summarized ten points that are important for a successful implementation of the CDIO initiative according to our experience. Below, we summarize the ten points roughly according to chronic order of consideration.

THE TEN POINTS FOR SUCCESSFUL IMPLEMENTATION OF THE CDIO REFORM

Commitments and Support from University and Faculty Leaderships

The CDIO reform should be carried out at program level and above. It covers almost every aspects of education, including the goals, objectives, stakeholders, curriculum, course syllabi, teaching philosophy, teaching and learning, workspace and facilities, faculty development and so on. It is nice for individual faculty to implement a few CDIO elements in his or her teaching activities. However, this kind of changes would not bring full benefits of CDIO educational reform. Individual faculty members cannot provide the necessary resources needed for the reform. Thus, it would be crucial to have full commitments and support from the university and faculty level management in terms of carrying out the changes and the essential resources required for the entire reform process.

The College of Engineering of STU has been very fortunate that we do have strong support from both university and faculty levels. The CDIO reform in the college has been headed by Provost and Vice President of the university, Dean of Engineering and Director of Educational Affairs. Though we have not been specially allocated more resources than other colleges within the university, a clear direction and firm commitments for the changes from the top had helped to remove many obstacles otherwise we be encounter. We have observed other successful and not so successful cases. Without exception, all successful implementations have been led or have got strong support from the top leaders.

Comprehensive Planning before Implementation

The CDIO reform needs a systematic approach. One must realize the complications of the educational reform. The first thing needs to be considered is to motivate the faculty and the students. The need for a change and the rational for embracing the CDIO initiative must be communicated with frankness and through thorough debates. External feedback from the industry and society in geneal would be helpful supports. The next is to establish confidence within the institution. Successful cases of other institutions can be collected and shared among the faculty and the students. The third would be right account of available resources, including facility and human resources. Workspaces and necessary facilities are deemed

necessary. A team of passionate faculty with relevant experiences is critically important, especially at the beginning of the reform. The forth and a very important point is to plan for continuous improvement right from the beginning. Many reform cases fail to proceed because short of new driving forces.

Integrated Solutions for Multi-tasks

We are in an era of fast and continuous changing. We daily face many tasks and changing requirements. It must be realized that quality education would always be the core business of an educational institution. The CDIO reform addresses the ultimate calling of engineering education. Thus, many of these tasks and requirements would be combined with the CDIO reform. By doing so we would encounter fewer resistances and make more effective uses of time and efforts of people involved.

By the time we started the CDIO reform, STU was preparing for the university wide accreditation of higher educational quality by Ministry of Education. This was the first ever exercise of such kind in the country. Given the importance and consequence of the accreditation results, everybody in STU was activated and was ready to contribute to teaching affairs. Therefore, it was much easier to organize seminars and carry out effective debates and discussions. Therefore, much of the work that we did, indeed produced dual effects: changing people's mindset and adding headline features into the accreditation reports. In addition, the CDIO reform has helped us to successfully apply for a list of national and provincial educational projects and awards.

Identifying Champions and Forming Core Team

Whenever a change is needed, some people are more willing than others to test and lead the change as champions. It is important to identify these people and have them form a team. With the help of these champions the change efforts would be multiplied and fast spread. It distributes the leadership among the champions and creates senses of achievement and ownership.

Unlike the situation in many universities in North America and Europe, the university administration is relatively powerful and has the tools and resources to initiate and making changes. This, in a way, can speed up a change process. However, it would, even if the direction is correct, create a team of passive followers. Once the leadership runs out of energy or has other priorities, the whole reform could stall. Hence, it is important that from the very beginning of the reform, the administration should identify the potential leaders emerging from the organization members.

Involve Most Faculty
Change from traditional education style to CDIO would need great changes in people's mindsets. Our experience shows that many basic concepts and practices required in the CDIO standards cannot be properly understood by simply reading the texts and the translations. This is especially true for people having less exposure to contemporary industrial and educational practices. Therefore, engaging everybody in the learning, discussing and implementing processes is a crucial measure to ensure that the reform reaches its goals.

We arranged a list of discussions, seminars and debates of all scale ranging from course level, program level, department level to college level. Results showed that discussions and seminars alone were not enough for in depth understanding.

All faculty members were asked to look into the courses they were teaching and to suggest modifications to the course structures of their respective programs. By doing so, the faculty

were provided with an opportunity to rethink on what they might take as granted. At the same time they could try to apply what they have learnt from the CDIO initiative. The result of the exercise revealed that faculty members have very different understandings. It highlighted a misconception in the course of discussions and seminars, during which it seemed that a unanimous understanding of the CDIO initiative had been reached.

Though the resulted syllabi might not be fully used, the exercise itself had been very useful. Firstly, it helped both the administration and the faculty to realize that to change the mindset of staff would need more efforts. Secondly, the exercise exposed some unreasonable aspects in the old program curricula. Lastly and the most importantly, an exercise like this involves everyone into the mindset-shifting process. Everybody actively reflects on the current situation and looks into solutions. It is therefore much easier for people to communicate on the "what" and "why" problems in the CDIO initiative. Consequently, the "how" problem would be understood and accepted correctly.

Innovative Implementation of the CDIO Initiative

The CDIO initiative answers "why" and "what" quite clearly. In term of "how" it gives guidelines stipulated by the 12 standards. The vast spaces have been left for innovation in implementing the CDIO initiative. Though a few implementation examples can be found in the CDIO resource center, it is important to find ways best satisfying our own requirements. Our approach has been learning and sharing among faculty and staffs. The process involves all relevant parties. It helps to establish consensus and ownership.

In the College of Engineering, STU, a "design directed" approach was taken as integration theme [4]. Here, the word "design" possesses a broader meaning than the "D" in CDIO. It covers conceiving, designing, prototyping, and testing. That is, it spans a large part of the CDIO life cycle. We believe that engineering design is the essence of engineering. Most technical knowledge and engineering skills and attitudes would be reflected in the engineering design processes. In addition, reflecting the need of the Chinese engineering education, we put special emphasis on professional ethics, integrity and professionalism in our education. Thus, we adopted the "designed directed EIP-CDIO" reform.

Piloting before Full Implementation

Though it has been discussed that the CDIO reform should be conducted at program level, it is still necessary to run a few pilot courses before full scale of implementation of the reformed curriculum and program structures. Indeed, the piloting the course could neither really prove nor disapprove the CDIO reform. However, the pilot courses are still meaningful and necessary. First, usually new curricula are only applied to newly enrolled students. Majority of faculty will not have the chance to teach the new courses in one or two year time. They would need to practice and accumulate experiences for the new ways of teaching before they have lost their interest, which might have been established through various kinds of activities. Second, there is a need to build up confidence needed among the faculty and the current batches of students, so that there can be a smooth transition from the old to the new curricula. Third, the process of piloting will cultivate more champion faculty in addition to accumulation of experiences.

Teaching pilot courses is different from conducting scientific experiments. The faculty members as well as the teaching environment change dynamically with the piloting process. Piloting will help establish the desired context for further reform. This has only been realized in our recent reflection.

Awareness of the Resources Constrains

Resources are crucial for the sustainability of reform efforts. Workspace, facilities and materials are the first list of items that must be considered. Students will need to carry out some design-build projects in the workspaces. The scales and the amount of work needed for the design-build items would need careful consideration. These will, to a large extent, determine or be constrained by the available resources.

Available technical staffs would be another constraint. Hands-on projects involve issues like safety and skills of operating machines. Many teaching faculty themselves are short of hands-on skills and/or engineering skills. Even if some faculty members have engineering and building skills, they may not be available all the time. In addition, many students only have time to do their projects outside normal working time. We have scheduled lab opening hours in the evening and in the weekends. But the availability of technical helpers is still a problem for us.

Support for Teaching, Learning and Leaning Assessment

For implementation of integrated learning, teaching, learning and assessment methods should be carefully chosen. Traditional approaches of teaching and learning would not be effective in this context. The CDIO resource center introduces some teaching methods. However, it would not be easily learned by reading only. Experiments and sharing experiences are excellent way of spreading new teaching and learning methods. It should also be realized that assessment schemes are also excellent guilds for both students and faculty in achieving dual learning effects.

In the College of Engineering of STU, each course or project aims to cultivate some the of CDIO skills. This is documented in the course syllabus. The faculty would need to find proper ways to fulfil the "I (Introduce)", "T (Teach)", "U (Utilize)" requirements stipulated in the course syllabi.

We have organised a list of workshops and seminars to share our ideas and experiences. This has helped us to enhance the teaching skills of our faculty.

Form Coalitions

The CDIO initiative is an open source, internationally collaborative effort. Collaboration among universities around the world makes the reform more effective and efficient. It also helps to coordinate efforts in establishing international trend of engineering education.

China has the largest number of engineering graduates each year in the world. Since the economic reform of the country, the industry and the society have been developed rapidly. There have been increasing needs for globally competitive talents. However, according to various reports, a large part of the graduate engineers do not meet these needs. It has become a challenge to find appropriate engineering employment for current graduating classes, especially during the current global economic crisis. To improve the competitiveness of Chinese industries, education of competent engineers and future industrial leaders is primary concern of the Chinese engineering educational institutions.

The CDIO initiative defines the goals and objectives that meet the global industrial needs. The principles of the initiative are based on well-established educational theories and best practices. Participating in the CDIO initiative has helped us in following the international trend, and narrowing the gap between the industrial needs and the engineering education. Thus we make every effort to disseminate the CDIO initiative to other universities in China. We have held a series of forums and seminars on engineering educational reform and introduction of CDIO.

With helps from the international CDIO leadership, under direction of Division of Science and Engineering, Department of Higher Education, Ministry of Education, two university coalitions have been formed in 2008. One of them is composed of over 30 universities. This group mainly works on the CDIO methods research and dissemination. The second coalition consists of 18 universities. This group of universities started pilot implementation of the CDIO initiative. Several participating universities have started fundamental reforms to their engineering education. By forming national coalitions, we have found partners and started building the momentum of the engineering education reform. This enhances our confidence in further engineering education reform based on CDIO, and helps us to carry on continuous improvements.

SUMMARY

The renowned leadership guru John Kotter [2] has listed eight steps for successful change management: 1. Establish a sense of urgency; 2. Form a Powerful Guiding Coalition; 3. Create a Vision; 4. Communicate that Vision; 5. Empower Others to Act on the Vision; 6. Plan for and Create Short-Term Wins; 7. Consolidate Improvements and Keep the Momentum for Change Moving; 8. Institutionalize the New Approaches.

A brief comparison between the eight steps and our ten key points would show that our reform management, though not deliberately following the eight steps, maps well with Kotter's guidelines. This demonstrates that both our experiences and Kotter's theory can be used for other insitutions to introduce the CDIO initiative in engineering education reform.

ACKNOWLEDGEMENT

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