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CDIO - An Educational Framework Innitiative for Undergraduate Programmes Training Improvements: A Feasible and Effective Choice For Ha Tinh University

HAI-NGOC TRAN
Senior lecturer, Ha Tinh University, Ha Tinh city, Vietnam
PhD candidate
Vietnam National Institute of Educational Sciences
Ha Noi, Vietnam
VAN-NHAN PHAN
Senior lecturer, Vietnam National Institute of Educational Sciences
Ha Noi, Vietnam

Abstract

The CDIO, initiated by Massachusetts Institute of Technology in USA, is an educational framework for training engineers. The framework stresses the engineering fundamentals in the context of Conceiving - Designing - Implementing - Operating real-world systems and products. The model has been adopted by CDIO collaborators and has expanded its scope to well-known international research institutions around the world and to other non-engineering study programs. The CDIO model is regarded as a potential approach to improve training quality and satisfy increasing requirements of employers based on determining graduates' education standards, and to develop training programs and plans. At Ha Tinh Univerisity, Vietnam, the CDIO innitiative has been applied since the school year 2016-2017 in different undergraduate study programs including engineering and non-engineering ones and it has proved to be rather effective.

Key words: CDIO, education standard, higher education, training quality

INTRODUCTION

The concept of CDIO was originally conceived at the Massachusetts Institute of Technology (MIT) in the USA in the late 1990s. Several years later in 2000, MIT collaborated with three Swedish universities - Chalmers University of Technology, Linköping University and the Royal Institute of Technology - formally founded the CDIO Initiative. It became an international collaboration, with universities around the world adopting the same framework (Bennedsen, Edström, Kuptasthien, Lauritsen, Roslöf, & Songer, 2019; Wallenberg Foundation, 2016). Wee (2010) stated that CDIO is an engineering education model adopted by leading engineering institutions in the U.S, Europe, Canada, U.K, Africa, Asia and New Zealand. Wee (2010) aslo said that CDIO Innitative is an inovative educational framework for producing the next generation of engineers. This framework offers an education stressing engineering fundamentals, set in the context of the Conceiving - Designing - Implementing - Operating process, which engineers use to create systems and products. Amstrong (2012) stated that the CDIO Initiative is an international initiative to reform engineering education, which involves collaboration among thirty-six leading engineering schools and departments from around the world. There has been an increasing number of schools and departments in leading engineering universities and institutes that have applied the CDIO approach and syllabus in teaching engineering students as well as students in many other disciplines (Amstrong, 2012; Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014).

The four higher education institutions are Chalmers University of Technology in Göteborg, the Royal Technical University in Stockholm, Linkoping University (Sweden), and the MIT. Crawley et al. (2014) stated that CDIO is an internationally great initiative to be established to meet a new decade's demand for enterprises and stakeholders in the world, with the goals to educate students who are able to master a working knowledge technical fundamentals, to foster in learning personal skills, communication skills, and lead in the creation and operation of new products, processes, and systems.

Until now, throughout the world, more than 165 institutions have adopted CDIO as the framework of their curriculum development in over 30 countries (Bennedsen et al., 2019; Malmqvist,

Edström, & Hugo, 2017). Some representatives include California State University and University of Michigan in the United States of America; University of Calgary and University of Manitoba in Canada; Telecom Bretagne in France, University of Auckland in New Zealand; University of Bristol, University of Leeds, and University of Liverpool in the United Kingdom; Sweden Chalmers University of Technology and Linköping University in Sweden; Helsinki Metropolia University of Applied Sciences, Kemi-Tornio University of Applied Sciences, Lahti University of Applied Sciences in Finland, University of Pretoria in South Africa, Nanyang Polytechnic, Tsinghua University in Singapore; Instituto Superior de Engenharia do Porto in Portugal, Queensland University of Technology in Australia (Bennedsen et al., 2019).

In Vietnam, the application of CDIO initiative has just been in an initial trial. In the academic year of 2009-2010, two Vietnamese national universities - Hanoi National University and Ho Chi Minh National University - applied CDIO in some training programs at their institutions (Dzung, 2012; Trinh & Khiem, 2012) and so far, CDIO-based training programs have been applied in eight universities in Vietnam including Ha Noi National University, Ho Chi Minh National University, Thu Dau Mot University, Duy Tan University, Da Lat University, FPT University, Vinh University, and Ha Tinh University (Hoa Binh, 2019).

THE ESSENCE OF CDIO

CDIO is an educational framework initiative for planning engineering programs. However, this framework is naturally a standardized training process in which it is based on the outcome of output to design the input criteria. This process is designed to ensure the rigor of scientific and practical importance. In general, in addition to its application in engineering field, the CDIO program is likely to be applied to construct a standard process for various training programs because this program ensures all the framework of knowledge and skills. For instance, the CDIO framework can be applied in disciplines of economics and business administration and in other training programs. As a result, CDIO is believed to provide an effective solution to enhance training quality to meet the society's needs.

In CDIO-based training program, students need to achieve four key areas of skills and knowledge, and after graduation, students are able to develop those skills and knowledge in working environment. The training objectives of CDIO are oriented to enable students to obtain necessary skills after graduation, to meet the employers' needs, as well as to keep up with constant changes in social life. Excellent students will be able to lead and turn necessary changes into achievable goals.

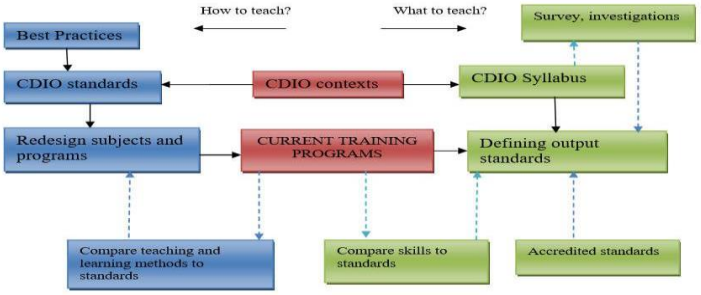

Figure 1. Implementing with CDIO Initiative (Crawley et al., 2014)

According to experts' evaluations, there are several benefits of training in CDIO Initiative. Firstly, it can create a link between training institutions and recruitment units; therefore, it can narrow the gap between the training institutions and the requirements of human resources recruiters. Secondly, it helps students to develop their necessary skills comprehensively to rapidly adjust themselves in constant changes of working and living environment and even the students can be leaders of such changes. Thirdly, it helps to create a standardized training program and process. Furthermore, there is a continuum and a close link in phases of the training program. Finally, it will link the development of training program with the effective implementation and evaluation at higher education institutions, which improves the quality of higher education.

THE CDIO CRITERIA

Crawley (2011) lists twelve descriptive standard criteria in CDIO program as follows:

Standard 1 - CDIO as Context: *Adoption of the principle that product and system lifecycle development and deployment - Conceiving, Designing, Implementing, and Operating - are the context for engineering education.*

Standard 2 - CDIO Syllabus Outcomes: *Specific, detailed learning outcomes for personal, interpersonal, and product and system building skills, consistent with program goals and validated by program stakeholders.*

Standard 3 - Integrated Curriculum: *A curriculum designed with mutually supporting disciplinary subjects, with an explicit plan to integrate personal, interpersonal, and product and system building skills.*

Standard 4 - Introduction to Engineering: *An introductory course that provides the framework for engineering practice in product and system building, and introduces essential personal and interpersonal skills.*

Standard 5 - Design - Implement Experiences: *A curriculum that includes two or more design-impliment experiences, including one at a basic level and one at an advanced level.*

Standard 6 - CDIO Workspaces: *Workspaces and laboratories that support and encourage hands-on learning of product and system building, disciplinary knowledge, and social learning*

Standard 7 - Integrated Learning Experiences: *Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal, interpersonal, and product and system building skills.*

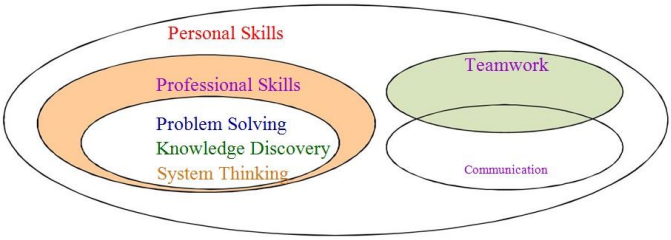

Figure 3. Venn diagram of personal, professional and international skills adapted from Crawley (2001).

Standard 8 - Active Learning: *Teaching and learning based on active experiential learning methods.*

Standard 9 - Enhancement of Faculty CDIO Skills: *Actions that enhance faculty competence in personal, interpersonal, and product and system building skills.*

Standard 10 - Enhancement of Faculty Teaching Skills: *Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning.*

Standard 11 - CDIO Skills Assessment: *Assessment of student learning in personal, interpersonal, and product and system building skills, as well as in disciplinary knowledge.*

Standard 12 - CDIO Program Evaluation: *A system that evaluates programs against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement.*

It can be stated that the CDIO Initiative was originally applied for training courses in mechanical and engineering. However, after reviewing the twelve standards of the CDIO program listed by Crawley (2001), it is possible to identify that the CDIO can be applied for training courses in different disciplines in undergraduate programs. It is because that the twelve descriptive criteria of the CDIO program meet almost all necessary features of learning skills, teaching skills, and assessment in disciplines of such programs including business administration. As a result, there is an increasing number of leading institutions and departments in multidisciplinary universities, and research institutes in the world that have adopted the CDIO framework for their training courses in the field of social sciences.

CDIO AND OUTPUT STANDARDS

According to engineering training programs, CDIO model is constructed based on careful survey, research on market's demand. They are shown in four key categories of skills and knowledge: (1) technical knowledge and reasoning; (2) professional and personal

skills and attitudes; (3) interpersonal skills and attitudes; (4) CDIO in social and enterprise context.

4. CDIO		
1.Technical knowledge and reasoning	2. Personal and professional skills	3.Interpersonal skills and attitudes

Figure 4. Building blocks of knowledge, skills, and attitudes necessary to Conceive, Design, Implement, and Operate Systems in the enterprise and social context adapted (Crawley et al., 2006)

The three initial categories are the basic foundation for the fourth category. It means that when students graduate from a university, they will achieve C-D-I-O (Conceiving, Designing, Implementing, and Operating). After finishing the output standards, academics should integrate the output standards into their teaching plans. This process includes five steps: (i) academics should organize seminars or workshops to inform the program to other academics and people involving into it; (ii) academics then integrate the program into their teaching plans; (iii) the scientific board of examination evaluate that program; (iv) academics modify their program if having, according to the board's advice; (v) the board certify that teaching program. However, CDIO is not a rigorous approach because the program designer is able to base on the outcome standards to adjust the program flexibly to meet the requirements of non-engineering disciplines.

CDIO AND THE DESIGN OF UNDERGRADUATE TRAINING PROGRAMS

According to CDIO Initiative, when designing and developing training programs, the designers have to follow the process rigorously: constructing output standards, designing a framework and the ways to implement it, and evaluating the study outcomes as well as the whole training program. The central principle of CDIO is its training program. This is considered as a statement of program objectives with 12 CDIO standards that are designed to reach these goals.

CDIO reaches the objectives of developing higher education (HE) with 12 standards, designing the training programs from a basic level to an advanced level, learning environment and space, evaluating learning programs, integrated course books or active teaching and learning approaches. According to many current training programs, HE institutions often provide training programs, and then define output standards. This causes the labour-recruitment units to have troubles in their work, especially in their recruitment of high quality human resources. Indeed, in Vietnam many recruiting organisations have to retrain or offer some extra courses to provide other necessary knowledge and skills for their newly-recruited staffs. Meanwhile, CDIO-based training courses provide high quality human resources because they are designed, based on the careful investigation and survey on practical needs of societies that recruitment organisations require. As a result, it contributes to reducing the cost and resources related to training. For students, they are trained in a fundamental way, improving their knowledge, skills, and attitudes. For academics, they have to apply innovative teaching methods that meet the requirements of scientific research. Therefore, it is essential for them to become internationally high quality staff.

Additionally, CDIO Initiative is likely to help to have a comprehensive revision of teaching and learning approach, and evaluating students' outcomes and academics' abilities. Besides providing a sample of output standards, CDIO Initiative may provide specific guidance on training and educational management such as viewpoints of businesspeople, leaders in higher education, project-based learning, innovating training framework, transforming informal communication skills, active and experienced learning, learning environment, testing and evaluating. As a result, CDIO is greatly useful in application and implementation.

In CDIO training program, each learning course, dependent on its aspects, partly contributes to achieve output standards of the whole training program. Therefore, each academic has to follow the regulations of the training program, and commits to deliver output standards of the subject that individual academics are responsible for

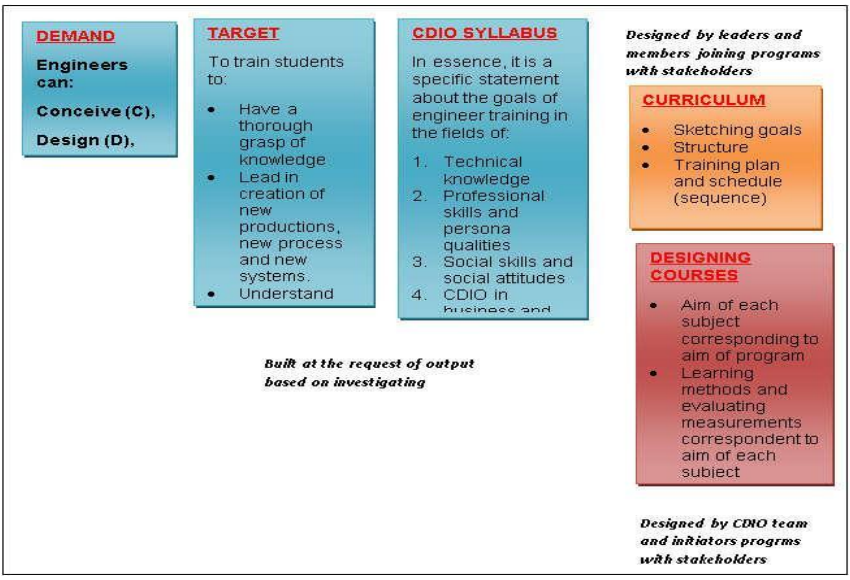

Figure 5. Process of building the content of training program based on CDIO (Crawley, 2001)

In conclusion, it can be remarked that CDIO Initiative provides not only output standards but also specific guidance about training, educational management: leadership styles, higher education management, and development of mastery disciplinary staff, a close link between industry and HEIs, a project or team-based learning approach, active or experienced-based learning, design of program framework, learning environment, testing, evaluating, and internationalization of higher education and son on. As a result, it is possible to say that CDIO Initiative is useful in implementing effective undergraduate training programs for higher education institutions in general and Ha Tinh University in particular. It has been one of the feasible and effective solutions to enhance the training quality of training programs including the business administration program at Ha Tinh University for three years so far.

However, the concept, process and application of CDIO are still new issues to the University. Obviously, in order to implement CDIO-based programs including the business administration one successfully at Ha Tinh University, it needs the following basic conditions: infrastructure, academic staff, technicians, training

programs, other facilities and students, etc so that they can meet the basic CDIO standards. Simultaneously, it should have a unifying standard system, process to ensure the success of program. CDIO Initiative requires following rigorously the process from the stage of investigation and survey to define real social needs of training products to the stage of building, designing, organizing, and evaluating the program. These are really great challenges towards higher education institutions in Vietnam in general and Ha Tinh University in particular. Yet, it does not mean that the CDIO Initiative can not be performed successfully in Vietnam. In our opinion, it is to make changes in applying CDIO to achieve and ensure the effective implementation.

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