

THE BENEFITS OF CDIO FOR ABET PREPARATION FROM A HANDS-ON STUDY IN VIETNAM

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ABSTRACT

This paper will focus on the analysis of where and how CDIO may benefit the most in the preparatory efforts for ABET accreditation. Using the data and assessments being prepared at Duy Tan University for ABET, the paper affirmed that previous adoption of CDIO at Duy Tan University has become very beneficial for ABET accreditation in a number of areas: First of all, for the ABET's alignment requirement amongst "Mission - Vision - Educational Objectives - Program Outcomes", the CDIO framework had provided very structured ways to deduct program outcomes from various educational objectives within the scope of its Standard No. 1 (The Context) and 2 (Learning Outcomes). Secondly, CDIO is essential in helping us meet most of the requirements of ABET's criteria about Students (ABET Criterion No. 1), Program Outcomes (ABET Criterion No. 3), and Continuous Improvement (ABET Criterion No. 4). Thirdly, the emphasis of CDIO on industry's involvement in curriculum development has given us good advice on how to set up and organize our Department Advisory Board for ABET. Fourthly, through the use of Student Portfolios, CDIO is especially helpful in documenting the levels of satisfaction for certain requirements and criteria of ABET. As a matter of fact, ABET accreditation are mostly based on relative assessment rather than some quantitative measurement scale, hence, it is sometimes difficult to determine how much more we need to try for to achieve certain levels of satisfaction. A number of direct and indirect assessment rubrics derived from the CDIO Framework such as English Writing rubric, Oral Presentation rubric, Teamwork rubric, Exit Survey, Employer Survey, etc. are quite useful in measuring our level of satisfaction for different ABET requirements.

(271 words)

KEYWORDS

CDIO Syllabus, ABET, Learning Outcomes, Education in Vietnam, Standards: 1, 2, 3, 7, 10, 11, 12

INTRODUCTION

The Higher Education (HE) in Vietnam is still considered backward compared to that of the rest of the world. So far, there is no university or college in Vietnam which is in the charts of the Top 400 schools of the Times Higher Education World University Rankings or in the charts of Top 600 schools of the QS World University Rankings. Degrees and diploma of HE in Vietnam has not been recognized in many developed countries. The desire of people working in HE in Vietnam is to improve the quality of training and to empower our educational position in the international arena for worldwide recognition of our degrees and diplomas. Many solutions have been proposed and carried out including the construction of educational quality assurance systems, participation in international networks for quality promotion and worldwide recognition.

Currently, the progress toward the formation of the ASEAN Economic Community (AEC) in 2015 has been up to 80% completed. So, there is an increasing pressure on the HE of Vietnam to make drastic and proactive changes toward regional educational integration. The HE integration at this point is no longer within any one country, but on the scale of the whole ASEAN. This clearly would require changes in the practice and working process of educational approach, students' recruitment, and management activities. Besides, the signing of the Agreement of Movement of Natural Persons (MNP) in ASEAN by the Vietnamese Government in 2012 is another big challenge to the labor market of Vietnam. Vietnamese universities and colleges would need to improve on the quality of its graduates. Otherwise, new graduates from Vietnam would become unemployed right on its "home field" because they cannot compete with the labor from neighboring countries. Vietnamese universities and colleges also would need to proactively link up with local and international businesses for job opportunities, vocational guidance, and employment counseling. Vietnamese students, on the other hand, should try to equip themselves with the right skills and knowledge, especially their English skill besides other regional cultural knowledge (Gaston & Ochoa, 2014).

In this context, quality assurance of higher education through various quality control practices and approaches is essential for any change in the HE of Vietnam. According the review of some international quality-assurance organizations, the quality-assurance approach of Vietnamese HE is currently entangled in many procedural problems, which cause its changing process to slow down, as followed:

1. The Vietnamese HE quality assurance system on a national level is not complete. The international quality assurance agencies are not allowed in the country if they depart from the direct guidance and control of the Ministry of Education & Training (MoET). The National Council for Accreditation of Higher Education has not been established.
2. Many internal quality assurance practices are carried out in universities and colleges only as requirement to the external demand of the MoET. The demand and purpose for self-improvement through internal quality assurance is weak in most institutions.
3. Current quality assurance mechanisms in Vietnam does not create the essential independence between 3 activities: self-assessment (by the school), external evaluation (by an independent accrediting or quality-assurance body outside the school), and the national HE quality recognition (by state agencies in higher education or through associations of universities and colleges).

4. The HE quality standards at this point have not demonstrated the right perspective stratification for the HE system in Vietnam.
5. There is still no universal system of quality standards is for the accreditation of individual training programs. The role of professional associations in accrediting individual training programs is completely absent.
6. Human resource in the national quality accreditation is lacking both in quantity, capacity and capability.
7. The transparency of data and information used for the evaluation process is low.

In recent years, with the move toward international integration and quality enhancement, the Ministry of Education & Training of Vietnam has gradually granted more autonomy to universities and colleges, permitting schools to set up internal quality-control units besides encouraging them to join in international quality-assurance networks in the region like the ASEAN University Network (AUN), the Asia Pacific Quality Network, and the International Network for Quality Assurance Agencies in Higher Education (INQAAHE). Vietnam's National Universities currently has 8 accredited programs by AUN (ASEAN University Network, 2014). Another 14 high-quality engineering programs at Hanoi University of Technology, Hanoi University of Civil Engineering, Da Nang University of Technology, the National University of Ho Chi Minh City, etc. have been evaluated in round 2 by the French Engineering Degrees Commission (CTI). On the other hand, some other Vietnamese universities have actively followed the accreditation process of international accrediting agencies like ABET (including the University of Da Nang, FPT University and Duy Tan University) or AACSB (including the International University in Ho Chi Minh City and Duy Tan University).

In general, there are currently only 40 out of 219 universities (or 434, if we also count the number of colleges) in Vietnam accredited by the national accreditation agency and another 8 academic programs accredited by AUN. This is a bleak picture about quality assurance of Vietnamese HE, but the real underlying problem may have to do with the lack of certain methodology for the preparation toward accreditation at many Vietnamese universities and colleges. In this paper, we will present a case study about the use of the CDIO framework in preparing Duy Tan University for its accreditation of the Software Engineering program with ABET.

ALIGNMENT AMONG MISSION - VISION - EDUCATIONAL OBJECTIVES - PROGRAM OUTCOMES

Mission

The very first requirement of ABET is the alignment between the Mission, Vision, Educational Objectives and Program Outcomes. So, while the full text of Duy Tan University's Mission Statement is as followed:

"With the Vietnamese spirit and the traditions of the historic Duy Tan movement, Duy Tan University makes the most out of its strengths and its close cooperation with domestic and international universities, enterprises, and individuals in order to become a multi-level, multi-discipline university, providing quality human resource of international standards in different lines of business and technology to serve the industrialization and modernization of Vietnam."

We can break it down into the following items:

- M1. Promoting Vietnamese values and principles
- M2. Disseminating multidisciplinary knowledge
- M3. Developing and internationalizing Vietnamese human resource through strategic collaborations
- M4. Achieving excellence and distinction in education, scientific research, and community service
- M5. Utilizing new and modern technologies

Vision

In order to carry out the above missions in the Software Engineering program (as well as in a series of other academic programs) at Duy Tan University, the university leadership chose the International School as a place to materialize its visions for an internationally-accredited Software Engineering program by:

- V1. Providing an excellent education for students
- V2. Generating new knowledge
- V3. Applying that knowledge to develop and implement solutions for global problems
- V4. Working with internal and external partners to conduct meaningful engagement
- V5. Stimulating local, regional and global economic development

Mission of the Software Engineering Program at DTU

“The mission of the Software Engineering Program at DTU is to provide a quality software engineering education with significant hands-on and industrial experience that will enable graduates to practice their profession with proficiency and integrity.”

Thus far, most of the alignments between the missions and visions of the university, its International School and its Software Engineering program are basically internal and self-alignments. Only the last part about the mission of the Software Engineering program indicated the requirements for quality engineering education besides industrial experience. How to realize those requirements is a different story, and this is where the CDIO framework enters the picture as a means to those end requirements. Interestingly enough, the very first educational objective that CDIO points out for today’s engineering graduates is their personal and interpersonal skills so as to survive in a culturally-diverse working environment (CDIO, 2010, Standard No. 2 and 7). Then, for the engineering expertise, students should have certain doctrine in their approach to any engineering problem: Process-oriented or outcome-oriented approaches are usually at the heart of most arguments, but given today’s great demand for innovation, the end outcomes should be what we need to focus on, to conceive and create some new engineering reality for mankind. For that reason, the Conceive-Design-Implement-Operate sequence of CDIO provides a better context than only Design and Implement of other process-oriented approach (CDIO, 2010, Standard No. 1).

Program Educational Objectives

Based on the guidance of the CDIO framework for training today’s engineers, we arrived at the Program Educational Objectives (PEOs) for our Software Engineering program, as followed:

- O1. Graduates are effective team members, aware of cultural diversity, who conduct themselves ethically and professionally.
- O2. Graduates use effective communication skills and technical skills to assure production of quality software, on time and within budget.
- O3. Graduates build upon and adapt knowledge of society, science, mathematics, and engineering to take on more expansive tasks that require an increased level of self-reliance, technical expertise, and leadership.

It should be noted that while O1 and O2 makes use of CDIO Standard No. 2, 7 and 1, respectively, O3 signifies some of the very first requirements of ABET for a strong education in basic sciences and a reliable technical capacity (Accreditation Board for Engineering & Technology, 2010). The requirements for leadership and cultural diversity, on the other hand, are more aligned to the mission statement of Duy Tan University even though they are also reflected at certain points by both CDIO and ABET in their requirements.

Consistency between Program Educational Objectives and the Institutional Mission

As our PEOs are mostly based on ABET criteria and CDIO standards while DTU's missions and visions are inherent to its core values, it is worth rating how well these values match up together to determine whether the eventual outcomes of our Software Engineering program will serve the right purpose.

Table 1. Match-up Ratings (on a scale of 0-5) between PEOs and Institutional Mission Components

<u>Mission Statement Components:</u> DTU Missions	<u>Program Educational Objectives: based on ABET and CDIO</u>		
	<i>O1. Graduates are effective team members, aware of cultural diversity, who conduct themselves ethically and professionally.</i>	<i>O2. Graduates use effective communication skills and technical skills to assure production of quality software, on time and within budget.</i>	<i>O3. Graduates build upon and adapt knowledge of society, science, mathematics, and engineering to take on more expansive tasks that require an increased level of self-reliance, technical expertise, and leadership</i>
<i>M1. Promoting Vietnamese values and principles</i>	4		
<i>M2. Disseminating multidisciplinary knowledge</i>	1	3	
<i>M3. Developing and internationalizing Vietnamese human resource through strategic collaborations</i>		3	2
<i>M4. Achieving excellence and distinction in education, scientific research, and community</i>	2	2	5
<i>M5. Utilizing new and modern technologies</i>		3	2

In theory, if every goes well, then, we achieve our mission by producing graduates that achieve the listed PEOs. It is usually said that technology transfer is best accomplished through the transfer of human resource. Our graduates should take on what they have learned and disseminate it into the environments where they live and work after graduation. As they succeed and achieve the PEOs, they will create new knowledge and technology, thereby helping solve different society's problems. Our educational mission will then be fulfilled by producing graduates who are qualified in the field of Software Engineering with significant amounts of integrity and hands-on, industrial experience.

In reality, looking at the above ratings, it can be said that the Mission Statement Component M4 will be always realized through the achievement in any one of the PEOs - specifically, as long as our graduates present certain level of professionalism (O1), or succeed in their technical work (O2), or participate in important tasks (O3), they will achieve certain level of excellence and distinction. On the other hand, for M3 and M5, if the graduates can achieve either O2 or O3, then they will get the opportunity to adopt new technologies (M5) and to elevate the significance of Vietnamese human resource (M3). The weakest links, however, are with promoting Vietnamese values/principles - M1, and disseminating multidisciplinary knowledge - M2. While the dissemination of new knowledge can be achieved through professional practices and success, the promotion of Vietnamese values and principles would require additional local work through some educational style of Duy Tan University to its students.

Table 2. Match-up Ratings (on a scale of 0-5) between PEOs and Institutional Visions

<u>Mission Statement Components:</u> DTU Visions for International Programs or DTU International School Missions	<u>Program Educational Objectives: based on ABET and CDIO</u>		
	<i>O1. Graduates are effective team members, aware of cultural diversity, who conduct themselves ethically and professionally.</i>	<i>O2. Graduates use effective communication skills and technical skills to assure production of quality software, on time and within budget.</i>	<i>O3. Graduates build upon and adapt knowledge of society, science, mathematics, and engineering to take on more expansive tasks that require an increased level of self-reliance, technical expertise, and leadership</i>
<i>V1. Providing an excellent education for students</i>	3	4	4
<i>V2. Generating new knowledge</i>		4	3
<i>V3. Applying knowledge to develop and implement solutions for global problems</i>		2	2
<i>V4. Working with internal and external partners to conduct meaningful engagement</i>	2		1
<i>V5. Stimulating local, regional and global economic development</i>		3	2

Coming down one level to the missions of the International School of DTU for its programs (here for the Software Engineering program), we noticed from the ratings that the achievement of O3 - i.e., graduates' participation in expansive technical tasks will automatically satisfy all mission components of DTU's International School in terms of providing excellent education, generating new knowledge, solving global problems, creating economic development, etc. Achievement of O2 or graduates' success in their Software Engineering career, in many ways, also creates the same effect with the absence of meaningful engagement depending on the circumstances. The weakest link here is with O1 or that the achievement of cultural diversity and professionalism alone may not be adequate enough in satisfying most mission components for an international Software Engineering program.

STUDENTS, PROGRAM OUTCOMES & CONTINUOUS IMPROVEMENTS

Students & Program Outcomes

The requirements of ABET for Students (ABET Criterion No. 1) and Program Learning Outcomes (PLOs) (ABET Criterion No. 3) are actually interweaving into one another as presented in the list of ABET EC2010 Criteria:

- a. *An ability to apply knowledge of mathematics, science, and engineering*
- b. *An ability to design and conduct experiments as well as to analyse and interpret data*
- c. *An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*
- d. *An ability to function on multidisciplinary teams*
- e. *An ability to identify, formulate, and solve engineering problems*
- f. *An understanding of professional and ethical responsibility*
- g. *An ability to communicate effectively*
- h. *The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*
- i. *A recognition of the need for, and an ability to engage in, lifelong learning*
- j. *A knowledge of contemporary issues*
- k. *An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*

(Accreditation Board for Engineering & Technology, 2010)

between CDIO 1.3 and ABET k as well as the mild correlation between CDIO 1.3 and ABET a.)

4. Graduates are knowledgeable of the ethics, professionalism, and cultural diversity in the work environment. *(This corresponds to the strong correlation between CDIO 2.5 and ABET f.)*
5. Graduates can apply basic software quality assurance practices to ensure that software designs, development, and maintenance meet or exceed applicable standards. *(This corresponds to the mild correlation between CDIO 4.2 and ABET c as well as the strong correlations between CDIO 4.1, 4.2 and ABET h.)*
6. Graduates have effective written and oral communication skills. Graduates can prepare and publish the necessary documents required throughout the project lifecycle. Graduates can effectively contribute to project discussions, presentations, and reviews. *(This corresponds to the strong correlations between CDIO 3.2 and ABET g as well as CDIO 3.1 and ABET d.)*
7. Graduates understand the need for life-long learning and can readily adapt to new Software Engineering environments. *(This corresponds to the strong correlation between CDIO 2.4 and ABET i as well as the mild correlation between CDIO 2.4 and ABET k.)*

If we look at the list of correlations built into the PLOs of our Software Engineering program, many of the ABET Criteria are covered, including ABET Criteria a, c, d, f, g, h, i, k. So, that leaves out only the following ABET Criteria of b, e, j. For ABET Criteria of b and e, i.e., “an ability to design and conduct experiments as well as to analyse and interpret data” and “an ability to identify, formulate, and solve engineering problems”, respectively, these were very much already built into the Conceive-Design-Implement-Operate sequence of CDIO approach. As for the ABET Criterion j of “a knowledge of contemporary issues”, we can satisfy it through arrangements in our general education coursework.

Continuous Improvement

At the heart of the CDIO framework, continuous improvement is very much an essential component to help sustain the whole framework (CDIO, 2010, Standard No. 12). In 2012, when Duy Tan University first became an official member of CDIO, we quickly recognized the importance of the CDIO’s continuous improvement process in helping us identify certain quality-assurance areas that had not been fully covered (Patil & Gray, 2009). Another good thing was that CDIO’s continuous improvement process took into account many ABET Criteria, making it easy for us to monitor our progress with ABET accreditation. Last but not least, the continuous improvement standard of CDIO required the participation of all the involved stakeholders (Crawley et al., 2007), allowing for complete documentation of various activities, which is also a major requirement in ABET accreditation.

Our time before the adoption of the CDIO framework and CDIO’s continuous improvement process was, however, not as easy: Improvement efforts for different academic programs at DTU used to be carried out in a non-systematic way, and assessments of learning outcomes at the departmental level were usually superficial. This is not to mention of the many constraints imposed by the Ministry of Education & Training of Vietnam in terms of curriculum development and assessment methodology. Then, when we first adopted CDIO in 2010 with

certain guidance from Singapore Polytechnic, we only tried out a number of CDIO experiential courses to test whether they might help us improve our students' soft skills. It took a while before we realized that CDIO called for the whole restructuring of all of our engineering programs. And as part of the continuous improvement requirement of CDIO, we had to rebuild all of the PEOs and PLOs of our engineering programs. Then, in order to assess the performance of our PLOs, a variety of program evaluation methods were used to gather information from students, instructors, program leaders, alumni, employers, and other key stakeholders. Figure 2 below depicts the continuous Assessment Cycle for Quality Assurance that we have built as a result of our CDIO adoption.

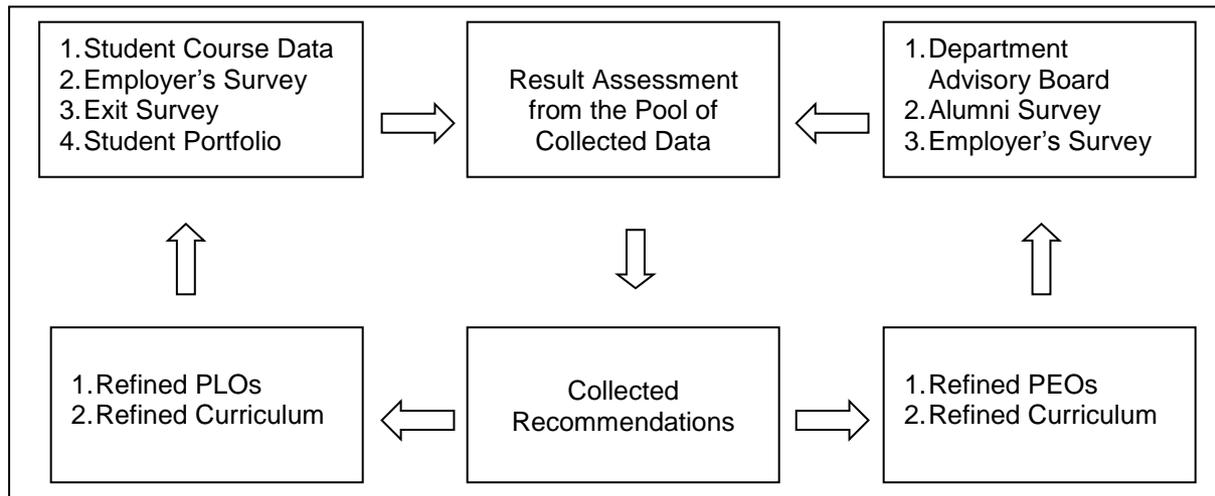


Figure 2. Assessment Cycle for Quality Assurance (based on CDIO's Continuous Improvement Requirement)

Based on the rationale of CDIO Standard No. 12, we realized that a great deal of data and evidence must be collected during the Program Evaluation process to serve as the basis of continuous program improvement. Our PEOs are assessed and evaluated every two years while our PLOs are assessed every semester and evaluated at the end of each academic year. We assess our PLOs through alumni surveys, employer's surveys, and meetings with our Department Advisory Board (Spurlin et al, 2008). The results of these surveys indicate how well our graduates are performing in their jobs or if the graduates are pursuing some advanced/graduate degrees.

At the departmental level, the International School collects its alumni and employer's surveys every two years. They also meet up with the Department Advisory Board twice per year. Alumni and employer's surveys provide necessary information for the assessment and evaluation of the PEOs of our Software Engineering program. These types of surveys look into issues like team performance, communication skills, and career development. The obtained results are shared with the right personnel of the International School and the Department Advisory Board to help determine the extent to which we are meeting our PEOs and whether any immediate actions are needed. Considering in our analysis for the alumni surveys and employer's surveys, a PEO is said to be achieved if it scores an overall average of 80% or above. Alumni and employers helped indicate the set of strengths in our graduates and suggested certain improvements in the Software Engineering program. The results obtained from the alumni and employer's surveys are presented in Figures 3 and 4. Based on the results from the Alumni Survey, it appeared that PEO O2 and O3 were achieved while

according to the results from the Employer's Survey, only PEO O1 was achieved. Given such conflicted feedbacks, we usually had to hold focus group discussions with both the alumni and employers to determine the true status of our PEOs.

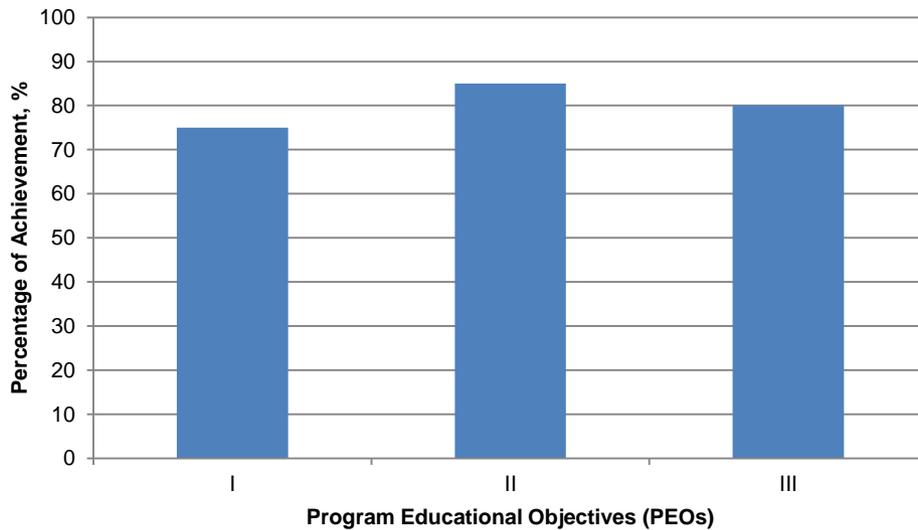


Figure 3. Alumni Survey Results

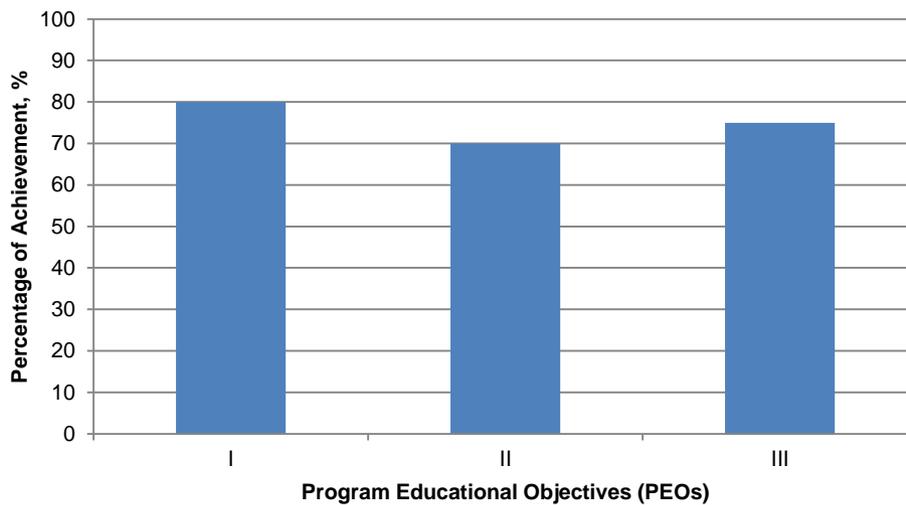


Figure 4. Employer's Survey Results

Our PLOs are assessed based on direct and indirect assessment methods (Accreditation Board for Engineering & Technology, 2010). The direct assessment methods are: Student Course Data and Student Portfolio. The indirect assessment methods are: Employer's Survey and Exit Survey. Instructors, on the other hand, use students' grades in exams, course project(s), and other rubric tools to assess PLOs. The rubric tools include: Teamwork rubric, Oral Communication rubric, Written Communication rubric and Technical Report rubric. We consider student achievement of a Program Learning Outcome is satisfactory if the assessment is 70% or above (following traditional Vietnamese grade point standard). Otherwise, it is not satisfactory and will raise a concern to the department. If the achievement

of a PLO is less than 70%, it is necessary to take proper steps to improve. The measures that we often use are: revising the curriculum or making certain courses mandatory. Figure 5 shows the achievement of each PLO (under ABET) based on our direct and indirect assessment methods while Figure 6 shows the achievement of one PLO based on the assessment from Student Course Data, Employer’s Survey, Exit Survey and Student Portfolio.

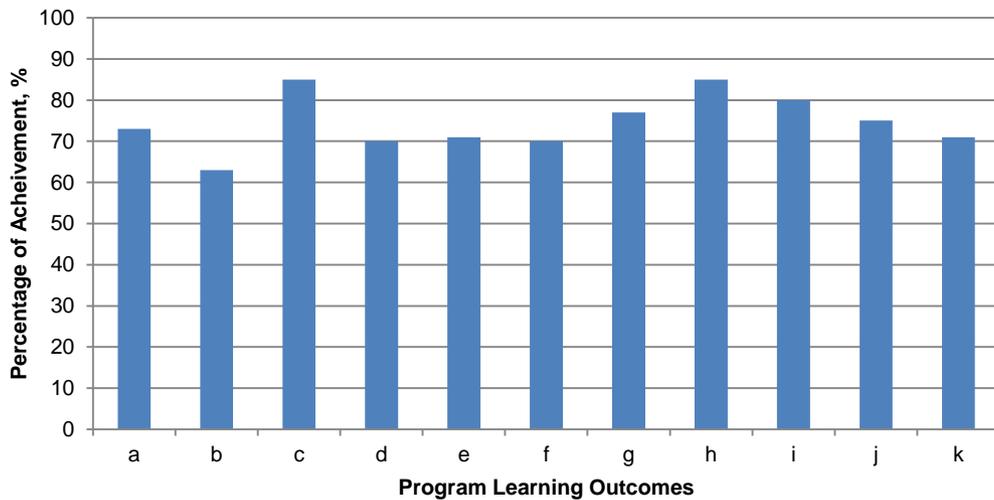


Figure 5. Average Achievement of PLO based on Direct and Indirect Assessment Methods

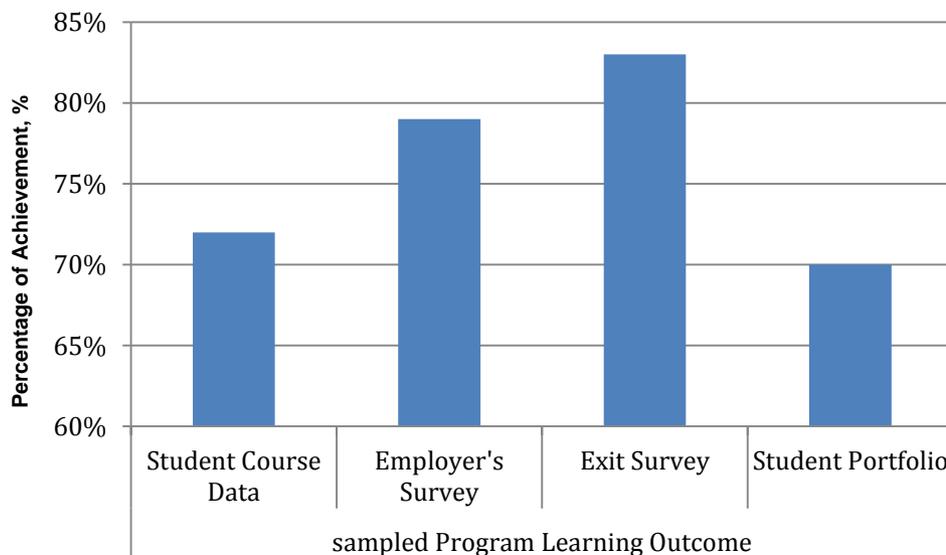


Figure 6. Achievement of a sample PLO based on Direct and Indirect Assessment Methods

DEPARTMENT ADVISORY BOARD

Even though the mission of our Software Engineering program stated very clearly that we “provide a quality software engineering education with significant hands-on and industrial

experience”, for quite some time, we did not have an advisory board for the program. Most of our communication with the industry went through a University Advisory Board, which helped cover many different programs of DTU. This centralization created a lack of focus on specific disciplines. As a result, when we adopted CDIO, its emphasis on direct industry’s involvement in curriculum development immediately called for the creation of the Department Advisory Board for the International School. The new Department Advisory Board consists of not only faculty members but also industrial partners and other key stakeholders, for a total of eight members. The Department Advisory Board meets twice per year, in the Fall and Spring semesters, to analyze certain findings and provide feedbacks and suggestions for the improvement of our Program Educational Objectives. They help assess our progress towards meeting our PEOs, and propose improvement solutions. In addition, the members of the Department Advisory Board also:

- Provide communication channel between the academia, the society and the IT industry;
- Stimulate the public's awareness of the need to create a high-quality IT workforce;
- Serve as a supporter of high-quality education in IT.

STUDENT PORTFOLIO

Previously, like other traditional programs at DTU, the students’ records in the Software Engineering program were not fully stored. The major records being stored were their final exam papers, for a period of two years, according to the regulation of the MoET. Therefore, we often did not know the extent of achievement in certain PLOs. The emphasis of CDIO on continuous improvement, however, requires the availability of every single piece of evidence to serve as the basis for change and improvement, and as a result, we had to build our Student Portfolios for that purpose. By now, we are able to assess different PLOs using Student Portfolios. As part of the procedure, students must complete and submit their Student Portfolios during the last semester of their graduation year. Students are also required to provide at least two artifacts that helped them achieve specific PLOs (Loewen et al., 2003). The proof can be an exam paper, a project, a presentation, a lab assignment, etc. A departmental committee will assess and evaluate the Student Portfolio through the use of a rubric for this purpose. Below is an example of a Student Portfolio:

Work samples (<i>graded and ungraded</i>)
Essays
Journals
Tests (<i>graded</i>)
Checklists
The projects
The achievements
The union/community activities
Results-scores
Self-assessment reports
The feedbacks

Figure 7. An example of a Student Portfolio

CONCLUSION

Given all the documentations, assessments and evaluations being prepared at Duy Tan University for ABET, this paper confirms that previous adoption of CDIO at Duy Tan University has become very beneficial for ABET accreditation in many ways. It helped determine areas of weakness or shortcoming in our ABET preparation and how to overcome different pitfalls. While the CDIO framework may not help cover all the problems posed in the ABET accreditation process, our initial experiences certainly showed that it comes quite close to meeting most of the essential requirements for ABET preparation. Thus, it can be arguably said that the CDIO framework is the best tool for ABET preparation.

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BIOGRAPHICAL INFORMATION

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