

CDIO and ABET accreditation – The Nanyang Polytechnic Experience

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ABSTRACT

This paper describes how the adoption of the CDIO Initiative at the School of Engineering, Nanyang Polytechnic, Singapore, contributed to the recent ABET accreditation of the Diploma in Aerospace and Aeronautical Engineering.

In this paper, we first describe the rationale for adopting the CDIO Initiative in the School of Engineering and how it is aligned with our unique Teaching Factory® concept and Contextual Teaching and Learning approach to produce future-ready graduates with good technical, professional and interpersonal skills.

Next, we will share our experiences in using the 12 CDIO standards as guidelines for course evaluation and a framework for continuous improvement since 2011. The CDIO annual evaluation process has paved the way for our preparation in meeting the ABET criteria. The areas of improvement identified through the annual evaluation process include the review of the internal assessments for the implementation of course objectives and learning outcomes, demonstration of continuous improvement cycle, the development of a course curriculum map, the improvements made to the module assessment components and assessment plan, the establishment of rubrics and other indirect methods to quantify various outcomes which cannot be measured using direct methods, the implementation of the Introduction to Engineering module, as well as enhancing the capability of our lecturers' CDIO and teaching skills.

Finally, we conclude that while CDIO played a key role in meeting the ABET criteria; the success of the accreditation within a short span of time is shaped by the strategic foundation for NYP organizational excellence - Culture, Concept, Capability and Connection /Collaboration.

KEYWORDS

ABET, Accreditation, Self-evaluation, Innovative Pedagogy, Organizational Excellence, CDIO Standard 12

Note – In the context of Nanyang Polytechnic, the term 'course' refers to a 'program' while the term 'module' refers to a 'course'. For example, *Diploma in Aeronautical and Aerospace Technology* is a course; *Introduction to Engineering* is a module.

INTRODUCTION

Nanyang Polytechnic (NYP) was accepted as a CDIO collaborator in 2011 and the course managers have since carried out self-assessments on their respective diploma courses annually by gathering evidences and using rubrics to rate its status (a score of 0-5) with respect to each of the twelve CDIO standards.

In this paper, we give a brief description on NYP Teaching Factory® (TF) concept and Contextual Teaching and Learning approach (CTL), the rationale for adopting the CDIO Initiative in the School of Engineering (SEG) as well as how it is aligned with our TF concept.

Next, we share our experiences in using the 12 CDIO standards as guidelines for course evaluation and a framework for continuous improvement and how this annual self-assessment exercise has paved the way for our preparation in meeting the ABET criteria for the Diploma in Aeronautical & Aerospace Technology (DAAT).

Finally, we conclude that while CDIO plays a key role in meeting the ABET criteria; the success of the accreditation within a short span of time is shaped by the strategic foundation for NYP organizational excellence - Culture, Concept, Capability and Connection /Collaboration.

NYP TEACHING FACTORY® AND CDIO

The TF concept is a unique pedagogical concept in NYP where we aim to provide students with an education that is driven by present and anticipated industry needs in order to produce industry-ready graduates with good technical, professional and interpersonal skills. A key aspect of TF involves simulating industry environments and facilities within the campus to emulate the real world where project work is an important integral component. Through close linkage with the industry (both locally and overseas) and government agencies (Roza, 2010), students will work full-time in a semester on projects from industry as well as in-house projects in an industry-like, project-infused training environment with real-life requirements and state-of-the art equipment.

For example, a “NYP Technology Park” was set up in the southern part of the campus in order for students to learn cross-disciplines teamwork and involve in innovative project work. The park houses all the technology-based courses in the School of Engineering, the School of Chemical and Life Science, the School of Information Technology, the School of Digital and Interactive Media and the School of Design. It is part of “Borderless Schools Concept” in the NYP model for organizational excellence (see Appendix A) that allows students and staff from various disciplines to interact through joint projects, cross-teaching and learning, with optimization of the utilization of resources.

We believe that students learn best when they are part of this environment and are engaged in learning both the science and art of engineering. In addition to applying their engineering knowledge, technology and techniques, they learn the culture of innovation and teamwork, sharpen their problem solving and communication skills, conduct their activities ethically and professionally, as well as learn to work with cost, quality, reliability and deadline constraints.

In the area of teaching and learning, Contextual Teaching and Learning approach (CTL) was adopted in NYP where lecturers relate subject content to real world situations and motivates

students to connect acquired knowledge to applications in real lives. The different schools in NYP will use a variety of teaching and learning approaches to match the learning outcomes, content and context of the disciplines that are covered in a school. In the case of School of Engineering, the CDIO program is adopted.

The rationale for adopting the CDIO program lies in the goals of the CDIO program. The goals of the CDIO program are to educate students who are able to master a deep working knowledge of technical fundamentals; lead in the creation and operation of new products and systems; and understand the importance and strategic impact of research and technological development on society. These goals are aligned to NYP's TF and CTL. That is, both aim to develop students who are industry-ready professionals.

SELF-EVALUATION OF COURSES USING CDIO RUBRICS

Since 2011, SEG has been a member of the CDIO initiative and we have been using the 12 CDIO standards as guidelines for course evaluation and a framework for academic design and continuous improvement in four theme areas: curriculum, workspaces, approaches to teaching and learning, and assessment practices. The evaluation is done using two documents: the CDIO standards evaluation with customized rubrics on a six point scale and examples of evidence of compliance.

In general, the feedback received from the course managers in using the rubrics to reflect the quality of the diploma courses is positive. They found the rubrics to be clear and usable. They also reflected that the examples of evidence of compliance with the CDIO standards help in collecting the types of evidences that are needed to determine the level of compliance with each standard. However, they felt that certain rubrics are subject to the interpretation of individual course manager and there is a need to contextualize the types of evidences required for each standard.

In order to have a consistent evaluation of all the eleven diploma courses that are offered in SEG, the school decided to standardize and contextualize the level of compliance to each of the CDIO standards. The next section describes the standardization process in details using the Diploma in Aeronautical and Aerospace Technology (DAAT) as a case study.

Self-Assessment Experience for DAAT

The DAAT course has a cohort size of 50 students and it provides a three-year practice-oriented and industry-relevant curriculum to students leading to a diploma qualification. The course embarked on its first course evaluation using the CDIO standards evaluation with customized rubrics in 2012. The evaluation results for DAAT from 2012 to 2014 are presented in Table 1.

With our TF concept and model of organizational excellence, DAAT fares well in the following standards: design-implement experiences (Standard 5), engineering workspaces (Standard 6) and enhancement of staff competence (Standard 9). In the area of enhancing staff teaching competence (Standard 10), the school has put in place a structured and customized program (Shankar & Suppiah, 2014) to provide support for staff to enhance their competence in integrated learning experiences (Standard 7), active and experiential learning (Standard 8),

and assessing student learning (Standard 11). Research will be conducted to study the impact and effectiveness of the implementation that was carried out for the 7 standards that are mentioned above.

Table 1. Rubric Scores (0-5) for DAAT from 2012 to 2014

CDIO Standard		2012	2013	2014
1	CDIO as Context	3	3	3
2	Learning Outcomes	3	3	4
3	Integrated Curriculum	3	4	4
4	Introduction to Engineering	2	4	4
5	Design-implement Experiences	3	5	5
6	Engineering Workspaces	4	5	5
7	Integrated Learning Experiences	3	4	4
8	Active Learning	3	4	4
9	Enhancement of Faculty Competency	4	4	4
10	Enhancement of Faculty Teaching Competency	4	5	5
11	Learning Assessment	4	4	4
12	Program Evaluation	3	3	3

The standardization process for other CDIO standards is as follows:

Standard 1 – CDIO as Context

The level of compliance is at 3, that is, CDIO is adopted as the context for the engineering diploma courses and is implemented in one or more years of the course. In order to move to higher level of compliance, the course manager and his team is to include a description of CDIO in all of the course publications and websites, and they are to continue to communicate the CDIO principle of teaching and learning regularly to all stakeholders, especially the students.

Standard 2 – CDIO Syllabus Outcomes

The level of compliance is at 4, that is, the learning outcomes of the diploma course are aligned with institutional vision and mission, and levels of proficiency are set for each outcome. The process of establishing the learning outcomes which are adapted from the CDIO syllabus; setting the proficiency levels for each learning outcome; validating the outcomes with all stakeholders; reviewing the curriculum in order to align the learning outcomes from module to the learning outcomes at the course level, and from the course to institutional vision and mission are depicted in Figure 1. In order to move to higher level of compliance, the existing Curriculum Development & Review Committee and sub-Committee will regularly review the learning outcomes and make changes to the learning outcomes based on the stakeholder's needs.

Standard 3 – Integrated Curriculum

The level of compliance is at 4, that is, there is evidence that personal, interpersonal, product, process, and system building skills are addressed in all modules responsible for their implementation. The evidences include the Integrated Curriculum Map (see Figure 2), mapping of learning outcomes at the module level to those at the course level, aligning the learning outcomes by module coordinators and include these alignments in the Module Synopsis, Syllabus, and Instructional Outcome and Module Assessment Plan documents. In order to move to higher level of compliance, the existing Curriculum Development & Review Committee and sub-Committee will regularly review the integrated curriculum and make recommendations.

Standard 4 – Introduction to Engineering

The level of compliance is at 4, that is, there is documented evidence that students have achieved the intended learning outcomes of the introductory engineering course. In 2012, one gap identified by the course manager and his team from the self-assessment exercise was the absence of an introductory module that matches the requirement of this standard. In 2013, the introduction to engineering module was implemented in the curriculum of DAAT. The course manager and his team believed that by including the introduction to engineering module in the first semester of students' first year of study will further stimulate students' interest in, and strengthen their motivation for, the practice of engineering through problem solving and design.

The implementation of the introduction to engineering module in DAAT course followed the general framework (Goh, Lim, & Ang, 2014) that was developed at the school level. The framework emphasizes the relevance of knowledge covered in the first semester of study to the engineering disciplines, and the use of this integrated knowledge in engineering practices, as well as the essential personal and interpersonal skills. The feedback received from staff and students were positive and encouraging since its implementation in 2013. In order to move to higher level of compliance, research will be conducted to study the impact and effectiveness of the implementation.

Standard 12 – Program Evaluation

The level of compliance is at 3, that is, the program evaluation methods are being implemented across the course to gather data from students, faculty, course leaders, alumni, and other stake-holders. The evidences include the enhanced Module Review Report that is to be prepared by module coordinator to evaluate the achievement of the learning outcomes at the module level; the enhanced Curriculum Review Report that is to be prepared by course manager to evaluate the achievement of the learning outcomes at the course level; and the CDIO Self-assessment Report that is to be prepared by course manger to evaluate the level of compliance to the twelve CDIO standards. In order to move to higher level of compliance, more data are to be gathered from all stakeholders, for example conduct exit interview with graduating students on their views of the learning outcomes.

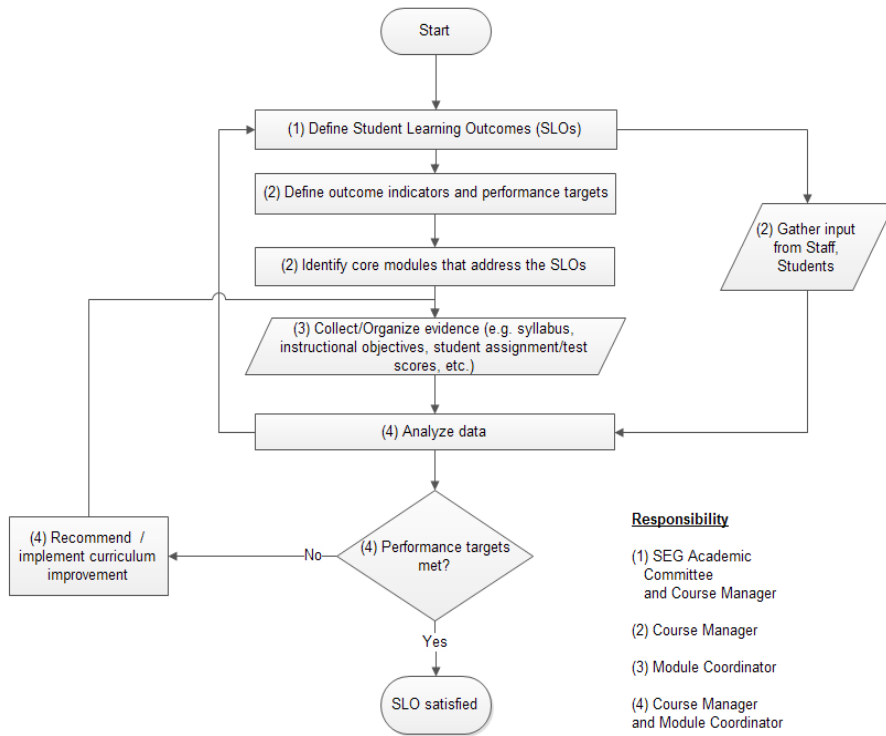


Figure 1. Process to establish and review learning outcomes

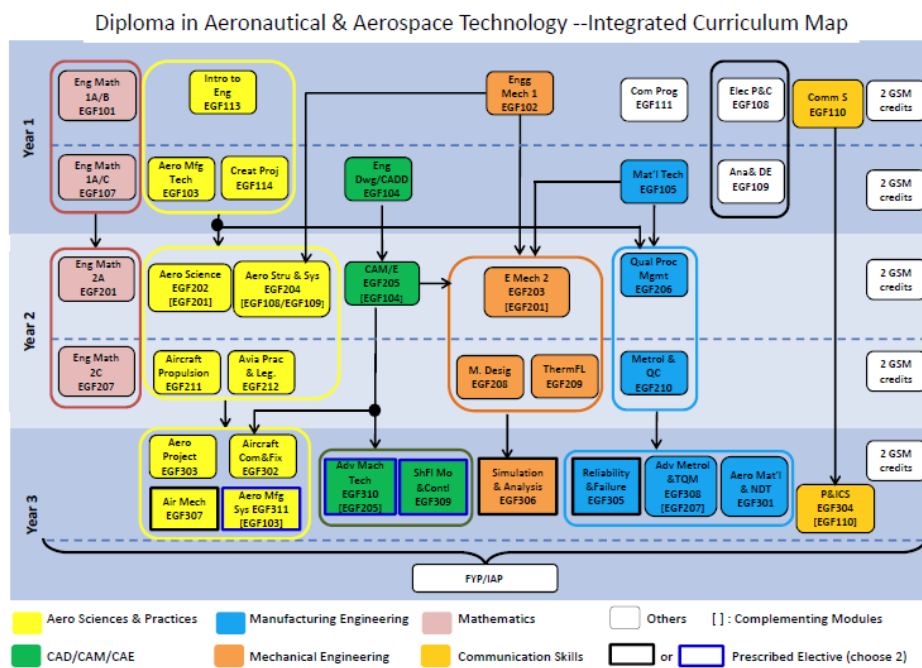


Figure 2. Integrated Curriculum Map

ACCREDITATION OF DAAT

As a CDIO collaborator, SEG is committed to perform self-assessment of its courses in seeking not only to meet the CDIO standards but to continuously seek ways to enhance the quality of education and training provided. In the case of DAAT, the CDIO development since 2012 has created some positive impacts and results for its students. These provided the course manager and his team the confidence in getting the course evaluated by an international panel. The purpose is to validate that the DAAT course meets standards of quality set forth by an international accrediting agency and that our graduates are adequately prepared for the practice of aeronautical and aerospace engineering technology worldwide.

Through research and interaction with relevant engineering accreditation agencies such as the Institution of Engineers, Singapore (IES) showed that ABET Accreditation by Engineering Technology Accreditation Commission (ETAC) is the most relevant and suitable accreditation for engineering & technology diploma courses. ABET Accreditation is also recognized by the Council for Higher Education Accreditation (CHEA) in USA and supported by the Singapore Ministry of Education. At the end of 2012, the school decided to have ABET accredited the DAAT course.

The first step towards the accreditation process was to prepare a readiness review report for DAAT which was to be sent to ABET for evaluation in the second quarter of 2013. There are eight ABET general criteria for technology program accreditation:

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|-----------------------------------|--------------------------|
| 1. Students | 5. Curriculum |
| 2. Program Educational Objectives | 6. Faculty |
| 3. Student Outcomes | 7. Facilities |
| 4. Continuous Improvement | 8. Institutional support |

The emphasis of these criteria is on outcome assessment-based improvement of engineering programs and requires academic programs to define and measure desirable outcomes for their graduates and be engaged in cycles of continuous improvement based on assessment data.

As highlighted by Costa et al (2012), the CDIO standards cover most of the criteria except for Criterion 8 (Institutional Support) and partially for Criterion 1 (Students) and Criterion 7 (Facilities). The following list aspects of ABET criterion that are not covered by CDIO standards:

- Criterion 1 – The program must have and enforce policies for accepting both new and transfer students, awarding appropriate academic credit for courses taken at other institutions, and awarding appropriate academic credit for work in lieu of courses taken at the institution. The program must have and enforce procedures to ensure and document that students who graduate meet all graduation requirements.
- Criterion 7 – The library services and the computing and information infrastructure must be adequate to support the scholarly and professional activities of the students and faculty.

- Criterion 8 – Institutional support and leadership must be adequate to ensure the quality and continuity of the program.

These criteria, however, are easily addressed by NYP's ISO-9000 academic quality assurance framework which is a procedural approach to quality assurance. The well-documented procedures span from the initial intake to course design and development, delivery, assessment and review.

The evidences and action plans that were implemented and documented since 2012 in the annual CDIO self-assessment reports proved to be useful when we prepared the Preliminary Self-Study Report to meet the requirements for all the criteria. In addition, the internal CDIO self-assessment process and experiences have also encouraged more team-based action planning, dissemination of good practices, learning about quality processes, and enhanced status of work. All these contributed to a successful on-site review by the ABET auditors in the fourth quarter of 2013.

The DAAT course was successfully accredited in 2013, making it the first engineering diploma course in Singapore that is accredited by the Engineering Technology Accreditation Commission of ABET. The successful coverage of ABET criteria was possible as NYP's leadership and dedicated colleagues together embrace NYP Organizational Excellence Framework. Such organizational culture and values foster staff to be engaged in program evaluation, rather than merely focused on conforming to the minimum program evaluation requirements. With this deep seated culture, we were able to address all ABET criteria adequately.

CONCLUSION

Program evaluation is important as it allows the school to determine whether the course is effective in carrying out the planned activities, and the extent to which it is achieving its learning outcomes. Using the CDIO self-assessment rubrics to evaluate a course against the twelve CDIO standards has proven to be useful in course planning and implementation, and collecting the different types of information needed by the management for continuous improvement purposes. This will pave the way for any external evaluation and in the case of DAAT, a successful ABET accreditation.

While CDIO plays a key role in meeting the ABET criteria, the success of the external evaluation within a short span of time is shaped by the strategic foundation for NYP organizational excellence where our staff demonstrated pioneering and can-do spirit as part of a borderless culture. Moving forward, program evaluation using the CDIO self-assessment rubrics will continue to be integrated into the ongoing course development and management and it requires staff to continue to appreciate the value of program evaluation and the impact that decisions have on the course status.

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APPENDIX A – NYP++ FOUNDATION FOR ORGANISATIONAL EXCELLENCE

The NYP model for organizational excellence is a key enabler for TF. It comprises of 4 components, namely Culture, Concept, Capability and Connection/Collaboration (the 4Cs):

- Culture: We believe that, by design, we have people with a set of common organisational values including, among others, “the can-do spirit” and “borderless teamwork”
- Concept: We believe that we have many innovative systems and processes to deliver the desired outcomes of our mission. They include, among others, the Teaching Factory® concept for effective teaching & learning, the “Innovation Everywhere Framework” to promote innovation & enterprise, and the Accumulated Experience Sharing System (AES®) for knowledge management (Chung, 2010)
- Capability: We know that, to stay relevant to the needs of our customers and stakeholders, our staff and the entire Polytechnic have to possess a strong and comprehensive set of capabilities. Hence there is a lot of emphasis on systematic human capital development and capacity building
- Connection: We are effective and innovative because we are able to collaborate with a wide network of strong partners, leveraging on each other’s resources, expertise and capabilities. Our partners include industry and technology leaders, educational & research institutions, and economic & development agencies – both local and international

BIOGRAPHICAL INFORMATION

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