A case study on the enhancement of faculty teaching competencies in an engineering Diploma

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ABSTRACT

This paper describes the journey and discusses the approaches of enhancing faculty teaching competencies (CDIO Standard 10) for the Diploma in Aeronautical and Aerospace Technology (DAAT) at the School of Engineering (SEG) in Nanyang Polytechnic (NYP), Singapore.

In NYP, we value capability development and believe that training builds a culture of continuous learning that spurs our staff to improve their skills and knowledge. In addition to training on teaching and learning provided by the Centre for Professional and Leadership Development, the implementation of the CDIO Framework at SEG has allowed the school to put in place a more structured and customized program to provide support for faculty to enhance their competence in integrated learning experiences (Standard 7), active and experiential learning (Standard 8), and assessing student learning (Standard 11).

The development of the integrated curriculum required that the faculty deliver not just technical content but also impart personal, interpersonal, product and system building skills. The interconnectivity between the modules in the integrated curriculum reinforced learning outcomes. After analyzing the gaps in faculty competency, a training plan was developed. The faculty was trained to formulate module learning outcomes using the Blooms Taxonomy of cognitive domain. The faculty was also introduced to active learning strategies which could be interwoven into their lesson to actively engage student attention and encourage class involvement. Black and William (1998), Shepard (2000) and Brookhart (2003), state that assessment is a moment of learning. The assessment methods were aligned to the learning activities and outcomes (Biggs 2003). This resulted in a shift from faculty-centric to student-centric outcomes, lessons and assessments.

The strategies in designing the staff training program, as well as the strategies to encourage and support staff in the educational change effort will be highlighted in the paper. The paper also examines the critical factors for ensuring a successful transformation and identifies the challenges faced in managing such change. Finally, we outline the future course of action to be put in place to enhance faculty effectiveness in helping students to be better prepared to meet the rigors of the engineering profession.

KEYWORDS

faculty competency, integrated curriculum, active learning, learning outcome, outcome-based assessment, rubrics

INTRODUCTION

Engineering faculties in higher educational institutions are expected today to meet the rigorous quality standards required by the engineering field as well as national and international accreditation bodies (A S Patil, P J Gray, 2009). Engineering education is often evaluated to ensure continuous curriculum reforms (Gruba, P, Moffat, A, Sondegaars H, and Zobel, J, 2004).

The Diploma in Aeronautical and Aerospace Technology (DAAT) at the School of Engineering (SEG) in Nanyang Polytechnic (NYP), Singapore recognized that enhancing faculty teaching competencies approach was the key to initiating and achieving the implementation of an integrated curriculum within the targeted time frame of 2013. Therefore the SEG top management together with the SEG Academic Development Committee adopted and adapted the CDIO Standard 1 (CDIO as a context) and CDIO Standard 2 (CDIO Syllabus Outcome) as the main underlying framework for the DAAT integrated curriculum. These were disclosed initially to key program designers and ultimately communicated progressively to module curriculum developers who were to be very involved in revising the diploma's course contents, documentations and methods.

In an effort to continually improve itself and meet higher standards, DAAT evaluated its own program (CDIO Standard 12) by focusing and investigating its educational contents and pedagogical methods. It concluded that there was a need for revision and undertook to formalize the diploma syllabus based on outcomes and conform its alignment (J Biggs, 1996) with CDIO Standards. Subsequently it translated its educational programs into integrated learning experiences (CDIO Standard 7), active and experiential learning (CDIO Standard 8) and skills assessments (CDIO Standard 11) through enhancing its faculty teaching competencies (CDIO Standard 10) in 2013.

The structure of this paper starts with a section describing the journey and discussing the approaches of enhancing faculty teaching competencies (CDIO Standard 10). It details the development of a structured training program that prepared faculty to implement CDIO Standards at the school and how it provided support for staff to further enhance their competence. The paper then examines the critical factors for ensuring a successful transformation and identifies the challenges faced in managing such change. The conclusion includes an outline of the future course of action to be put in place to enhance faculty effectiveness in helping students to be better prepared to meet the rigors of the engineering profession.

Enhancing Faculty Teaching Competencies

In NYP, past records proved that a staff is effectively spurred to improve their skills and knowledge mostly through training which helps build a culture of continuous learning. Valuing capability development, systematic, comprehensive structured training programs were prepared by the Academic Development Committee in SEG to train and prepare the faculty of the DAAT for the implementation of CDIO.

The structured training programs were designed and developed to train staff to construct learning outcomes for their modules[1] based on the revised Bloom's Taxonomy (Anderson, et. al., 2001), as well as to train them to plan learning activities and assessment tasks to have better alignment with the learning outcomes (J Biggs, 1996) so that students are able to construct meaning from what they do to learn.

Before the launch of the training programs, the first task was carried out by the course[2] management team together with the SEG Academic Development Committee and other stakeholders to redefine the Course Educational Objectives (CEO) for DAAT. The CEOs describe the academic and professional accomplishments that the course or the institution is preparing students to achieve. The Course Educational Objectives for DAAT are aligned and consistent with NYP's vision, mission and core values. To deliver the CEO, Student Learning Outcomes (SLO) were defined. The SLOs were developed as part of the DAAT course development through the extensive efforts of the faculty and environmental scan, with feedbacks from students, alumni and industry.

Structured Training Programs

Mapping of SLOs achieved in a module

After identification of the SLOs, the next step was to identify the modules which contributed to each of the SLO. A series of training programs were planned and implemented to complete this exercise. About forty module coordinators and supervisors were trained in the process of identifying the SLOs which were to be achieved in their modules. The module coordinators were also briefed on the performance indicators and targets that are expected from each SLO (see Figure 1) so as to enable them to identify the relevant SLOs to be achieved in their modules. These would subsequently be translated into designing learning activities and assessment tasks that are aligned to the SLOs (see Figure 2).

Student Learning Outcome	**Performance Indicator**
Function effectively in a multi-disciplinary team	1) Recognize participant roles in a team setting and fulfils appropriate roles to assure team success 2) Integrates input from all teams and makes decisions in relation to objective

Figure 1. A sample of performance indicators

[1] In NYP, "course" is referred to as "module".
[2] In NYP, "program" is referred to as "course".

Student Learning Outcomes				(a) apply the knowledge, techniques, skills and modern tools appropriate to aviation related disciplines	(b) apply basic knowledge of the following aerospace fields: aerodynamics, flight dynamics, propulsion and structures/materials	(c) apply a knowledge of mathematics, science, engineering and technology to solve aviation problems	(d) apply CAD/CAM, engineering topics and aeronautical science for aviation applications	(e) conduct evaluation, analyse results, design, develop, test and implement solutions	(f) function effectively in a multi-disciplinary team	(g) communicate effectively through written, oral and visual means	(h) recognise the need for and engage in lifelong learning	(i) recognise the need for and a commitment to professional and ethical responsibilities	(j) recognise the need for and engage in innovative and enterprising activities
s/n	Module Code	Module Title	Module Coordinator										
1	EGF101	Engineering Mathematics 1A/B	Zhang Hedan			X				X	X	X	
2	EGF102	Engineering Mechanics 1	Mohd Shah		X			X	X	X	X	X	X
3	EGF108	Electrical Principles & Circuits	Foo Kok Sey Harry	X		X					X	X	X
4	EGF110	Communication Skills	Ng Agnes					X	X	X	X	X	X
5	EGF111	Computer Programming	Wong Looi Kian			X		X		X	X		

Figure 2. A sample of the mapping of module to SLOs

Revisions of relevant documents for outcome-based learning

Interactive hands-on sessions involving a total of ten to twelve module coordinators together with their supervisory staff in each session were organized. Document template changes were also highlighted and information shared on how to use the revised Bloom's Taxonomy (see Figure 3) to revise Synopsis, Syllabus and Instructional Outcomes documents so that they are aligned with the SLOs. Bearing in mind the principles of andragogy, time was also given for the module coordinators to do a hands-on to refine the original documents of the Synopsis, Syllabus and Instructional Objectives using the new document templates (see Figure 4 and 5). The faculty was actively encouraged to complete the exercise and their efforts presented for peer comments. Many were elated that they had gained confidence in the process and prepared to revise the necessary documents after the training sessions.

In addition to the hands-on sessions, faculty was also given access to online self-paced learning material as an additional platform to refresh their learning as they worked on revisions of the relevant documents (see Figure 6).

I - Remembering	II - Understanding	III - Applying	IV - Analysing/Evaluating/Creating		
arrange, bookmark, bullet-point, cite, collect, define, describe, duplicate, enumerate, favourite, find, Google, highlight, identify, label, list, locate, match, memorize, name, order, outline, quote, recall, recognize, record, relate, repeat, reproduce, retrieve, search, select, show, social bookmark, social network, state,	annotate, associate, blog, categorize, classify, comment, compare, contrast, convert, defend, describe, differentiate, discuss, distinguish, estimate, exemplify, explain, express, extend, generalize, give, give example(s), identify, indicate, infer, interpret, justify, locate, outline, paraphrase, predict, recognize, restate, review, rewrite, search, select, subscribe, summarize, tag, translate,	apply, calculate, carry out, change, chart, choose, classify, complete, compute, construct, contribute, demonstrate, develop, discover, dramatize, edit, employ, execute, experiment, extend, hack, illustrate, implement, instruct, interpret, load, manipulate, modify, operate, participate, play, practice, predict, prepare, produce, relate, run, schedule, share, show, sketch, solve, teach, test, upload, use, write,	analyse, appraise, attribute, break, breakdown, calculate, categorize, classify, collect, compare, connect, contrast, correlate, crack, criticize, deconstruct, deduce, diagram, differentiate, discriminate, distinguish, divide, establish, examine, experiment, explain, identify, illustrate, infer, investigate, link, mash, mind map, model, order, outline, pointout, prioritize, question, relate, reverse engineer, select, separate, subdivide, test, verify,	appraise, argue, assess, attach, choose, collaborate, compare, conclude, contrast, convince, criticize, critique, debate, decide, defend, describe, detect, determine, discriminate, discuss, estimate, evaluate, explain, grade, interpret, judge, justify, moderate, monitor, network, post, prioritize, rate, recommend, reflect, relate, review, score, select, summarize, support, value, weigh,	adapt, animate, anticipate, arrange, assemble, categorize, collect, combine, comply, compose, construct, create, design, develop, devise, direct, explain, film, forecast, formulate, generalize, generate, hypothesize, imagine, incorporate, integrate, invent, make, mix, modify, organize, originate, plan, podcast, predict, prepare, produce, program, propose, publish, rearrange, reconstruct, reinforce, relate, remix, reorganize, revise, rewrite, setup, structure, summarize, synthesize, tell, validate, video blog, videocast, wiki, write,

Figure 3. Revised Bloom's Taxonomy and the action verbs (Anderson, et. al., 2001)

No	Topics	Instructional Outcomes	L	T	P	Cognitive Skills Level*
5.4	Multi-dimensional Arrays	• Define and implement multi-dimensional arrays				III
6.0	**Functions**		2	2	4	
6.1	Introduction	• Define Modular Program Design • List the elements of modular programming • Describe the steps in modularization				II
6.2	Function Definition	• Describe the basic concept of C functions • Implement a function (prototype)				II

Figure 4. A sample of Instructional Outcomes and Cognitive Skill Level

Learning Outcomes :

At the end of this module, students will be able to:

1. analyze and model software solutions to given problems [SLO – c,e,h]
2. write and test software codes to given problems [SLO – c,e,h]
3. integrate and present the developed software solutions [SLO – g,h]

Figure 5. Sample mapping of Module Learning Outcomes to Student Learning Outcomes

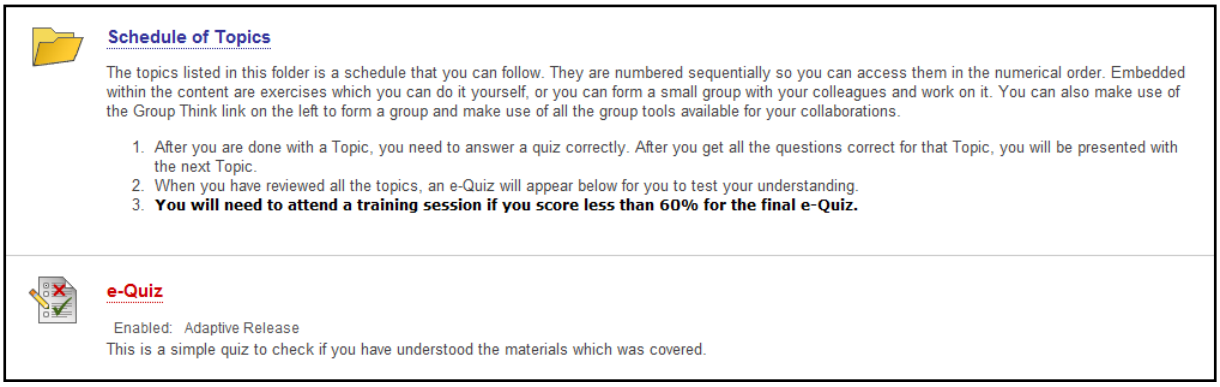

Figure 6. Online self-paced learning material snapshot in Blackboard

Follow-up training sessions were then carried out to review documentations with focus on the learning outcomes and assessment tasks. Findings from a review of selected revised documentations of outcomes were shared and there was evidence that the earlier interactive training sessions were effective as a majority of the module coordinators had used correct phrasing of outcomes in the Syllabus and Instructional Outcomes documents. An on-line tool to check action verbs based on the revised Bloom's Taxonomy (see Figure 7) was also introduced in these sessions for module coordinators to verify their revised documents. The

tool enabled faculty to input an action verb to find out if it was included in the revised Bloom's Taxonomy and the cognitive level it could be pitched at.

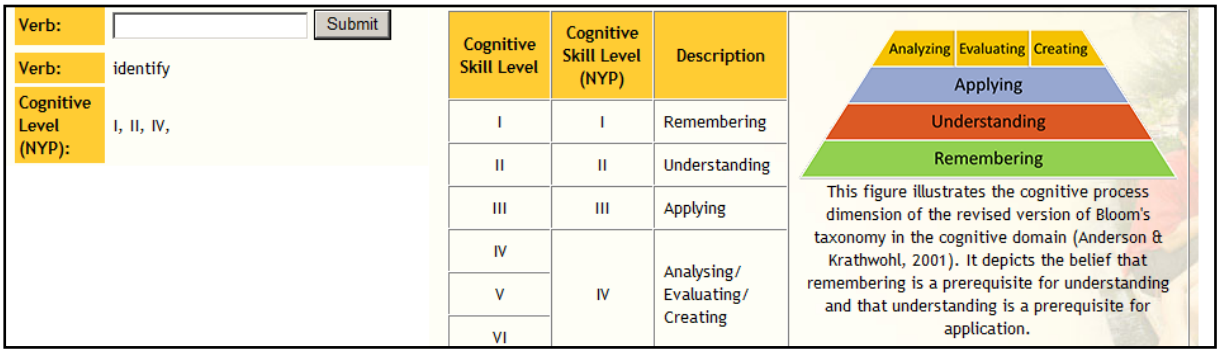

Figure 7. Online tool to check action verb in Bloom's Taxonomy

Once the revision of the documents were completed, the next series of training sessions covered the planning of the assessment tasks that are to be aligned with the SLOs and performance indicators (see Figure 8). The emphasis was on producing evidence of student learning. Thus, it was important for faculty to plan effective assessment methods to assess different learning outcomes. For example, to map to SLO like 'communicate effectively through written, oral and visual means;' assessment methods like presentation, class participation, group assessment, etc. should be considered as the means to assess students' oral and visual communication. For written communication, the assessment method could be tests, assignment, reports, lab worksheets, etc. These training sessions provided hands-on activities for faculty to review their documentations and assessment plans based on the set learning outcomes.

ASSESSMENT PLAN

Assessment Components	Percentage (%)	Assessment Methods	Applicable
Class#	20	Assignment / Report	☐
		Participation	☒
		Presentation	☐
		Quiz	☒
Practical	20	Lab Worksheet/Report	☐
		Lab Assessment	☒
Project	30	Individual Assessment	☒
		Group Assessment	☒
		Presentation	☐
Test	30		
Examination			
Total	100		

Figure 8. A sample Assessment Plan

Rubrics to assess outcome-based learning

In addition to planning assessment tasks that are aligned to the learning outcomes, faculty is encouraged to use rubrics as a standardized way of assessment by stating clearly the criteria and weightage for the different components of assessment. Through the use of rubrics, students will be clear on the expectations of quality for assignments and they will understand the reasoning behind a grade. In SEG, rubrics are further refined to assess students'

performance in teamwork, individual contribution, class participation, and presentation, in order to have a better alignment with the learning outcomes and performance indicators.

Training sessions were then organized to train faculty on the use of these refined rubrics. Each rubric has two forms: Form A and Form B. Form A is for faculty use and they can input the actual marks for each criteria of the rubric. Form B is for faculty to discuss with students on areas that students had done well and areas that needed improvement. In order to encourage more faculties to use rubrics to assess student learning, a flow chart on how rubrics can be implemented in a module had been developed (see Figure 9).

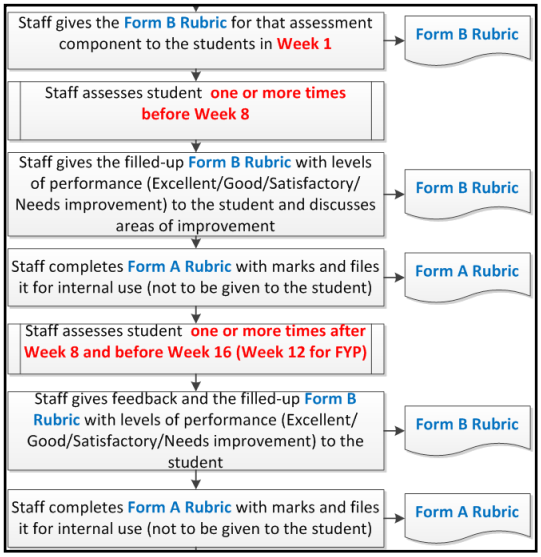

Figure 9. Flow chart for implementing rubrics in a module

In these training sessions, the rubric feature in the Blackboard Learning Management System was also introduced as an alternative tool to using the forms (see Figure 10).

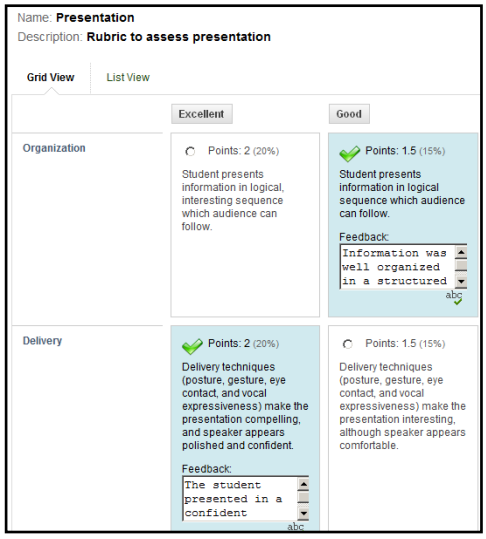

Figure 10. Snapshot of a graded rubric for presentation

Active Learning Strategies

The last part of the structured training programs is on planning of learning activities in the classroom, with a focus on active learning strategies. While active learning methods have been used by faculties, sharing sessions were constantly organized to share with the faculty some of the latest trend in using active learning methods to engage students directly in thinking and problem solving activities, to make connections among key concepts and facilitate the application of this knowledge to new settings. These sharing sessions also provided a platform for faculty to share their experiences and exchange ideas on best practices that they had used in their classrooms.

Some examples on active learning strategies are: retain student attention through brain teasers, checking student level of understanding through instant polling tools, team-based activities to promote collaborative learning through the use of scratch card or software, brain storming activities through the use of word clouds and other tools to generate surveys and multiple choice quizzes while teaching in the class.

Feedback on the Structured Training Programs

Faculty generally felt that they benefitted from the structured training programs. While the interactive hands-on segment was useful for a majority of the faculty, it was clear that the less confident ones would have benefited more with more time and personalized assistance given.

The training of faculty for outcome-based revisions of relevant documents was on the whole, effective and successful. Under the enhanced training program, the faculty was well trained to formulate learning outcomes using the revised Bloom's Taxonomy of cognitive domain. The faculty was also better informed on how to select assessment tasks that leads to the intended module learning outcomes. It was also encouraging to see many in the faculty using rubrics to assess student learning.

The students had also given feedback that they were able to understand the module learning outcomes better than before. They were also clearer about the assessment methods being used to test their learning.

For faculty who had tried the active learning strategies in their classes, the feedback received from students were encouraging. The students were fully engaged in such sessions and reported that they were able to learn better in such an environment.

Strategies for successful transformation

While the journey and process of implementing an integrated curriculum through structured training programs is challenging, the application of a definitive change management process facilitated the successful alignment with the CDIO standards. The key success factor was the ability to get strong support from school's management and faculty on the change. The management was provided with an overview of upcoming changes in relation to aligning with CDIO standards and had a clear understanding on what was expected of their faculty in the

process of change. As for the faculty, there was an open channel of communication where they were kept informed of every change being planned and they were adequately trained to incorporate the change.

The process also involved guiding the faculty using a participative structured training program approach adapted to the needs of the faculty to maximize improvement. Changes were identified, for example change in focus, change in ways of doing things, skills needed, structures to be modified and these were incorporated into the structured training programs. The whole process helped identify areas of operation that needed attention. It also helped to ensure that the faculty understood its roles and responsibilities clearly and set benchmarks for progress.

Finally the unique setup of the SEG Academic Development Committee, which has members who are a part of the faculty teaching the engineering diploma, was a key enabler of the change. Unlike many organizations where there is a central committee in-charge of the implementation for the whole institution, the CDIO implementation at NYP is decentralized and is implemented by the respective schools. The committee members were aware of the training needs of the faculty and enjoyed a good rapport with the faculty. The faculty experienced trust, respect, teamwork and communication which assisted in enhancing faculty teaching competencies in a shorter time.

Conclusion

The SEG Academic Development Committee, encouraged with its experience of enhancing faculty teaching competencies (CDIO Standard 10) through training of faculty, is now geared to do the same for the faculty of the other engineering diplomas that are offered in the school. The journey to achieve faculty effectiveness is an on-going one and experience gained from the case study from the DAAT will prove useful in enhancing the faculty capability for the other SEG diplomas.

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BIOGRAPHICAL INFORMATION

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