SUSTAINING CDIO CAPABILITY VIA MENTORING OF ACADEMIC MENTOR

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ABSTRACT

This paper presents the effort by the Diploma in Chemical Engineering (DCHE) of Singapore Polytechnic (SP) in implementing CDIO Standard 10 "Enhancement of Faculty Teaching Competence", which focus on maintaining our CDIO Competency via the training of an Academic Mentor. The paper first provides a short background literature review of the changing role of engineering educators, in light of changing student characteristics in today's globalized, inter-connected world. The paper then presents the desired characteristics of an engineering educator and highlights the lack of emphasis given to their training; and calls for a more professional approach to preparing them, noting in particular the importance of mentoring. This paper also presents a brief overview of academic mentoring arrangements and best practices as well as the benefits and challenges of mentoring. More specifically, this paper argues that engineering educator must be skilled in pedagogical content knowledge, and not only subject matter knowledge and general pedagogical knowledge. The paper then briefly explains SP's Academic Mentor Scheme and its broad objectives, and explain how we ride on the scheme to enhance our own CDIO capability, with specific objectives for DCHE Academic Mentor. We share a model of continual improvement from the research literature, which we find suitable for training of our academic mentor; and highlighted several benefits of our approach. The model emphasizes educational research that informs education practice that support professional development of the academic mentor. Lastly, the paper shares positive experiences from both mentor (the first author) and mentee (the second author) that has resulted from this partnership. We present a summary on how this partnership evolved, followed by key issues and challenges faced by both parties. These include matching of expectations between mentor and mentee and adopting of new pedagogic approaches (e.g., flipped learning and peer instruction, development of learning tasks based on dynamic simulation). We conclude by summarizing some key learning points that may be of interest to others involved in similar professional development activity.

KEYWORDS

Chemical Engineering, Mentoring, Continual Improvement, CDIO Standards 9 and 10.

NOTE: Singapore Polytechnic uses the word "courses" to describe its education "programs". A "course" in the Diploma in Chemical Engineering consists of many subjects that are termed "modules"; which in the universities contexts are often called “courses”. A teaching academic is known as a "lecturer", which is often referred to a as "faculty" in the universities.

INTRODUCTION

As a framework for re-designing engineering curriculum, CDIO had been adopted by many educational institutions worldwide. What sets it apart of other engineering re-design framework is the comprehensiveness of its approach, encapsulated in the 12 CDIO Standards. The two standards relevant to the professional development of lecturers as he/she undertake a career switch from the industry to academia are Standards 9 and 10, shown in Table 1.

Table 1. CDIO Standard 9 and Standard 10 (source: www.cdio.org)

No.	Standard	Description
9	Enhancement of Faculty Competence *Actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills*	CDIO programs provide support for the collective engineering faculty to improve its competence in the personal and interpersonal skills, and product, process, and system building skills described in Standard 2. These skills are developed best in contexts of professional engineering practice. The nature and scope of faculty development vary with the resources and intentions of different programs and institutions. Examples of actions that enhance faculty competence include: professional leave to work in industry, partnerships with industry colleagues in research and education projects, inclusion of engineering practice as a criterion for hiring and promotion, and appropriate professional development experiences at the university.
10	Enhancement of Faculty Teaching Competence *Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning*	A CDIO program provides support for faculty to improve their competence in integrated learning experiences (Standard 7), active and experiential learning (Standard 8), and assessing student learning (Standard 11). The nature and scope of faculty development practices will vary with programs and institutions. Examples of actions that enhance faculty competence include: support for faculty participation in university and external faculty development programs, forums for sharing ideas and best practices, and emphasis in performance reviews and hiring on effective teaching methods.

The Diploma in Chemical Engineering (DCHE) of Singapore Polytechnic (SP) had been using the CDIO Framework to re-design its 3-year curriculum since 2006. In the polytechnic, given the nature of our education, all lecturers are hired from the relevant industry. In fact, it is an institutional requirement that all potential employees must have at least 3-4 years of relevant experience working in the industry related to the job position applied for. As such, all DCHE lecturers are hired from the chemical processing industry rather than direct from teacher training colleges. Many of us have been schooled in relevant knowledge bases drawn from established educational perspectives and theories. The Department of Educational Development then undertake the task of training them to become educators. Details of this had been described by Cheah & Singh (2011) elsewhere.

This paper is a follow-up to our earlier effort, with the explicit focus on mentoring of academic mentor, in particular to build CDIO capability espoused in Standard 10. The approach we had taken is that of research-informed training for DCHE academic mentor. The paper first provides a short literature review of mentoring in engineering education. It then briefly explains Singapore Polytechnic's Academic Mentor Scheme, followed by detailed discussion of DCHE's effort in training its staff as academic mentor, with emphasis on building the mentor's CDIO Capability, using examples of best practices gleaned from the literature.

MENTORING FOR FACULTY (LECTURERS) IN ENGINEERING EDUCATION

The context of teaching in higher education has changed significantly in the past decade, especially in light of changing student characteristics in today's globalized, inter-connected world. King (1993) coined the catchy terms “Sage on the Stage vs Guide on the Side” to highlight the changed role of lecturers. Much had been written about competencies and skills needed in engineering education (see for example, Passow, 2007; Redish & Smith, 2008). However, very little is written about how we prepare, or who is best suited to prepare, our lecturers to deliver the revised engineering curriculum most effectively (Jamieson & Lohmann, 2009). One reason for this could be the outdated assumption that most faculty are already prepared for their careers due to extensive research in their field and because of their existing relationship with dissertation students (De Janasz & Sullivan, 2004).

Not realizing that there are many ways in which learning can be made more effective and interesting to students, new lecturers typically tend to default to the relatively ineffective teaching methods they experienced as students (Felder, 1993). This is very important, as improving engineering education must begin with the people on the “front lines” of education (Ambrose & Norman, 2005), i.e. the lecturers.

As noted by Morell and DeBoer (2010): "Much has been said about the profile of the engineering graduate of the future and about effective and innovative teaching and learning strategies, yet only a few have spoken about the skills and competencies of the ideal engineering professor – key individual of the heart of the process education." The authors called the set of desired skills and competencies of an ideal engineering professor the "forgotten variable” in the education process; and argued that if these and similar skills and competencies will be required from the engineers of the future, then they will also be required from those who will be educating those engineers of the future.

In this context, Morell and DeBoer pose the essential question of what is an "ideal professor?" Based on the 88 responses to their survey whereby recipients are requested to “list the top five (5) attributes of an ideal engineering professor", the authors presented the following profile of the Ideal Engineering Professor of 2020:

> A technical expert,
> ...with a savvy and adaptability rooted on actual engineering practice
> ...with superior communication skills
> …recognized as an effective teacher and mentor
> …and committed to ethical and inclusiveness abidance.

Adams and Felder (2008) proposed the following roles for engineering educators:

- Educational philosopher and provocateur
- Educational researcher
- Interdisciplinary educator
- Teacher leader
- Scholarly teacher and reflective practitioner

Kolari and Savander-Ranne (2002) suggested that professional learning must always be connected to context, and that engineering educators must be skilled in not only subject matter knowledge and general pedagogical knowledge, but more importantly in pedagogical content knowledge (Shulman, 1986). According to the authors, *pedagogical content knowledge* can be described as subject matter knowledge for teaching. It includes aspects of content most germane to its teachability or, in other words, the ways of representing and formulating the subject that make it comprehensible to others. Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. In short, pedagogical content knowledge can simply be seen as encompassing subject matter knowledge and general pedagogical knowledge, with an emphasis on a broad description of subject matter knowledge. Likewise, Morell and DeBoer (2010) noted that "engineering professors need to be both engineers AND (capital in original) educators and be trained and have experience in both disciplines. They need to both understand what it takes to practice the engineering profession and how to effectively facilitate student learning." All three elements are important to enable one to become a good lecturer. A study from Hynes (2007) concluded that:

> *"From a deeper look into subject matter knowledge, it is clear that a deep understanding of engineering would likely lead to stronger teaching. If a teacher has a deep understanding of the engineering principles at work, they will likely be better able to simplify some of the complexities of engineering into simpler forms their students will understand. ... Limited subject matter knowledge does not allow teachers to develop pedagogical content knowledge, which includes strong strategies, examples, or contexts for their students."* (p.58)

Lastly, a good lecturer should continuously observe and reflect on the teaching practice and its effect on student learning. As noted by Olsson and Roxå (2012), "…based on theoretical knowledge, where subject matter content knowledge, pedagogical content knowledge, as well as curricular knowledge, are of critical importance, and own observations of teaching and learning, the teacher analyses his or her teaching practice in relation to students' learning and draw rational conclusions and make plans for continued development. The teacher thereby demonstrates *pedagogical competence* (italics in original)."

The task of preparing a new lecturer for the role of teaching is often the responsibility of academic developer, or academic mentor. Fraser (2001) explained that "an academic developed is any person who has a role in which they are explicitly expected to work with academics to assist them to reflect upon their academic role in relation to teaching, research, scholarship, leadership, funding applications and supervision of students. An academic developer may also work at a department / institutional level in a development role." The challenge, however, is that there is no defined route to becoming an academic developer (McDonald & Stockley, 2008). Quinn and Vorster (2014) called for the systematic preparation of academic developers via formal courses.

Mentoring has increasingly becoming more important to help engineering faculty become better teachers (Boice, 1992; Felder, 1993), and several approaches had been offered by Stice et al (2000). It is not the purpose of this paper to discuss mentoring at depth, and only a brief overview is provided in the next section. Interested readers are referred to fine work of Zellers et al (2008). Suffice to note here is the comment by Felder (1993), in arguing for the need of mentoring, who stated that "Teaching – like medicine, auto mechanics, professional basketball, and chemical engineering – is a craft. There are distinct skills associated with its practice, and need years of training before they can function at a professional level." A statement from Ramsden (1992) is also worth repeating here:

> *"For too long we have relied in higher education on teaching that is essentially an amateur affair. A professional approach to teaching should be seen in the same light as a professional approach to law, medicine or engineering…. A distinctive characteristic of professionals is that they retain theoretical knowledge on which to base their activities. This body of knowledge is more than a series of techniques and rules. It is an ordered pattern of ideas and evidence that a professional teacher uses in order to decide an appropriate course of action from many possible choices."*

BRIEF SUMMARY OF LITERATURE REVIEW OF ACADEMIC MENTORING SYSTEMS

There are many types of mentoring systems. By far, one-to-one is the most common, which is also the one adopted by Singapore Polytechnic, to be discussed in the next section. Others include group mentoring (where one mentor meets several mentees at the same time), team mentoring (where several mentors work with one mentee), peer mentoring and reverse mentoring (where the mentor is a junior faculty and mentee is the more senior one). Hanover Research (2014) provides a good summary of these other mentoring systems. Often one institution may also utilize more than one mentoring systems, and the structure and format of these programs varies as well (Douah, 2007). For example, Wake Forest University School of Medicine, was cited in the Hanover Research as using all these forms. Another approach to faculty mentorship, which has also received support from an increasing number of institutions, is mutual mentoring (also known as network-based mentoring) pioneered by the University of Massachusetts Amherst's Center for Teaching and Faculty Development (Hanover Research, 2014). Mutual mentoring can be distinguished from peer mentoring, which being informal in nature, provides faculty of equal stature (experience and rank) with an opportunity to share interests and collaborate on their career development. Mutual mentoring, on the other hand, involves a broader, more flexible network of support that mirrors the diversity of real-life mentoring in which no single person is required or expected to possess the expertise of many (Sorcinelli & Yun, 2009). Based on a survey by Douah et al (2007), the most common areas (88% for each of the responses) in which mentors provide guidance, are helping with the tenure process, with publication, and with learning departmental and institutional norms; rather than in pedagogical areas.

The current literature on mentoring based on the CDIO Standards 9 and 10 are rather limited. Stressing the importance of faculty development, Edstrom (2012) had noted that educational development is generally insufficiently represented in research-oriented universities that prized research outcomes more than excellent teaching. Edstrom et al (2009) reported on the use of a Teaching and Learning in Higher Education course in a university as a way to satisfy the requirements of CDIO Standard 10. Malmqvist et al (2008) reported on different approaches taken by 3 CDIO university collaborators in managing pedagogical and professional competence development as a whole. A commendable effort in mentoring using the CDIO standards came from Loyer and Maureira (2014), who shared a 3-stage model based on on-the-job apprenticeship where both mentor and mentee co-teach the same class of students. The authors acknowledged that having 2 teachers dedicated to the same course during an academic term is a high cost for the school, but argued that this must be seen as an investment, given that this is a more effective way to enhance teaching competencies. Not every institution can afford such luxury. Another paper from Christiansen et al (2010), noted the establishment of "teacher teams" to sustain the CDIO implementation effort at their university, although the authors did not explicitly mentioning mentoring effort. They also noted the existence of a special career path which acknowledges special efforts and achievements related to teaching and education by faculty.

Douah et al (2007) identified the following best practices related to academic mentoring:

- Structured mentoring efforts, whereby guidelines and expectations are well established, are most effective
- Departments should spend time exploring and customizing mentoring programs that are best suited for their particular departmental culture and field
- Inter-disciplinary faculty mentoring should be explored whenever feasible
- Work/Life issues should be addressed, but not necessarily within the context of a departmental faculty mentoring program.
- To maximize the effectiveness of a faculty mentoring program, department chairs should check-in periodically with the mentoring that a mentee receives

A good discussion of the mentoring relationships is provided by Zachary (2000), who presented mentoring as progressing through 4 phases - preparing, negotiating, enabling, coming to closure - that build on one another to form a developmental sequence. Nick et al (2012) provide an overview of a model for excellence in establishing a formal mentoring program for academic nurse educators. The model is intended to be generalizable for faculty teaching in a variety of academic nursing institution types and sizes. In this model, six best practices - appropriately matching dyads, establishing clear mentorship goals, solidifying the dyad relationship, providing opportunities for the mentor to advocate for and guide the mentee, integrating the mentee into academic culture, and mobilizing institutional resources to support the mentoring relationship - are seen as key in supporting the four pillars of excellence in mentoring, viz. orientation of faculty role; socialization to academic community; development of teaching, research and service skills; and facilitation of growth of future leaders. Nick et al (2012) also reported on the many positive outcomes as a result of mentorship identified by research. For example, it was noted that when a novice educator is formally mentored by a more experienced and accomplished academician, the novice educator more quickly assumes the full scope of the academic role and is more productive Mentoring has also been reported to have contributed to higher career satisfaction and increased departmental or organizational morale. Mentees reported the following benefits: augmented professional identity, smoother bridge from practice to the academic environment, increased self-confidence and professional development.

Despite the widespread benefits to mentors, mentees and their organizations, some drawbacks to mentorship do exist (Coates, 2011). The most obvious is the amount of time the mentor spent on developing the mentee's career, which can drain the mentor of energy and productivity. Co-workers may resent the positive partnership, and mentors may receive negative fallout for appearing to favour their mentees. The mentors may feel a sense of personal failure if their mentees do not meet their expectations, and may be worried that their co-workers' opinions of them may also dwindle as a result of poor protégé performance. At times, the entire relationship can be detrimental. A well-meaning mentor may hold back a mentee who has surpassed the mentor's ability to help. Conversely, an outstanding mentee may threaten the mentor by exceeding his or her performance capabilities.

Lastly, in wrapping up this section, it is also worth noting that the majority of mentor program evaluations continue to be based on anecdotal information and participant reports and observations. A survey by Douah et al (2007) reported from their survey findings that 68% of departments with academic mentoring program in place did not have a method in place for assessing the effectiveness of their programs. Different outcome measures are often used to evaluate different programs, which makes it difficult to evaluate, interpret, and compare programs. Clutterbuck (2004) for example, suggested that mentoring effectiveness can be measured on two dimensions: relationships and programme, and from two perspectives: processes and outcomes. Berk et al (2005) reported on the development of two tools: the Mentorship Profile Questionnaire, which describes the characteristics and outcome measures of the mentoring relationship from the perspective of the mentee, and the Mentorship Effectiveness Scale, a 12-item six-point agree–disagree-format Likert-type rating scale, which evaluates 12 behavioral characteristics of the mentor. In addition, as noted by Foster (2001). evaluation descriptions are often not comprehensive enough to allow the reader to independently assess the quality of the evaluation and data. Other limitations include lack of funding or lack of follow-up studies to track long-term outcomes to determine if positive changes last over time, even though several approaches to program effectiveness evaluation are available (see for example, Grossman, 2009). It is therefore perhaps not too surprising that Gore et al (2004) concluded that despite the wealth of research and numerous initiatives, "most teacher educators would acknowledge that there is still a long way to go in ensuring that graduates will go on to become great (or at least good) teachers".

THE SINGAPORE POLYTECHNIC ACADEMIC MENTOR SCHEME

SP introduced the Academic Mentor Scheme in 2010. This initiative is an addition to existing faculty development program at SP. A comparison of professional development program in SP with other CDIO collaborators is presented by Kozanitis et al (2009). The broad role of Academic Mentor is to act as 'pedagogic catalyst', contributing to the improvement of quality in curriculum, teaching and assessment in SP. Being based in schools, they are able to combine working with their colleagues on specific school projects, as well as being part of wider communities of practices, addressing SP's key thrusts and initiatives. While school needs may vary in terms of focus, the broad areas of work of an academic mentor are as follows:

- Mentor and coach academic staff in all aspects of the professional teaching role in the SP context
- Provide consultation on curriculum design, delivery and assessment
- Establish school/department-based Teaching and Learning Units and relevant Communities of Practice
- Support and lead school/department and SP educational initiatives
- Coordinate and conduct educational research where necessary
- Work collaboratively with other AM's across schools/departments, especially the Department of Educational Development (EDU) faculty and external agencies in meeting desired educational goals

Trainees for academic mentor will need to undergo a one year training by Senior Education Advisor from the Department of Educational Development (EDU). The framework and general approach taken by SP, as well as the generic aspect of the academic mentors training is beyond the scope of this paper. However, it is noteworthy to highlight here that the SP Academic Mentor Scheme is not grounded in CDIO specifically, but rather to build up a talent pool of mentors in education in general. The scheme strives to provide an alternative career pathway for its academic staff who are interesting in mentoring activities. For a brief discussion of SP's Learning Roadmap, see Kozanitis et al (2009). Upon successful completion of their Academic Mentor training, the trainee will be designated as "Academic Mentor" instead of the usual designation of "Lecturer". Career-wise, progression parallels that of teaching staff, i.e. as Senior Academic Mentor and subsequently as "Principal Academic Mentor". With this, we hope to alleviate come of the concerns of lack of tangible incentive for academic staff to embark on mentoring activities. Academic mentors is expected to ride of existing platforms to share the work that they had done, e.g. monthly educational roundtable (Kozanitis, et al, 2009).

Trainees undergoing Academic Mentor program are required to work on a project of their choice. Since it is school-based, each diploma is given some flexibility to define its own specific areas of work for its academic mentor under training, over and above the broad objectives of academic mentor mentioned above. Discretion is left to the discussion between mentor and mentee in the respective school. This approach is consistent with the literature reviewed earlier that mentoring should be set in the context of the disciplinary area. A comparative study by Malmqvist et al (2008) on three CDIO university collaborators, also showed that there is no "one size fits all" approach to building faculty competency.

THE DCHE APPROACH TO MENTORING TO DEVELOP CDIO COMPETENCY

In DCHE, we hire industry practitioners who have a passion for teaching and train them to be lecturers. As they mature in their teaching career, our "industry-turned-academia" go through the same three stages of development (see Table 2) as that suggested by Fink et al (2005).

Table 2. The Three Stages of Engineering Educator Development

Level	Main Feature	Explanatory Notes
1	Enhance Common Teaching Techniques	When one first started his/her teaching career, and worked on improving one's teaching techniques, i.e. to learn more about the nuts and bolts of teaching, learnt to make lectures more interesting and engaging, how to prepare better exam questions, or how to use ICT to enhance lectures
2	Understand the Science and Principles of Learning and Teaching	One noted that a gap still exists between student performance and one's expectations; and moved on to explore in greater depth the principles of learning and how these can impact teaching; how to develop strategies that have proven to be effective in enhancing learning, to align assessments with learning tasks and learning outcomes; and engage students in a higher order of problem-solving
3	Explore the Humanistic Dimension of Education	One explored how to more fully understand and relate to students as human beings; to teach in an inspiring way to a new generation of "millennials"; what one can do to help students see the central role of learning in life and importance of personal growth

As they had no formal training in teaching beyond a very fundamental 1-year Certificate of Teaching course (as mentioned in previous section) at the time of employment, these lecturers lacked the requisite knowledge and skills in learning theories and their application to the practices of teaching. After several years of teaching, they are often 'stuck' at level 1, or at best level 2. Without help, they are not able to move beyond the level that they find themselves in. With the help of academic mentors it is possible to enhance the professional development and progression of these lecturers.

Our own approach to academic mentor training rides on the SP Academic Mentor Scheme, with some diploma-specific competencies as defined by the diploma Course Management Team. For the case of DCHE, we desire that an academic mentor:

- Is well-informed of the literature on engineering education in general, and in chemical engineering education in particular
- is familiar with the CDIO Framework, in particular, the self-evaluation process using CDIO Standards for module and course improvements
- will implement necessary changes in his/her module, and to assist colleagues, e.g. by designing a learning task in accordance with CDIO Standards to improve student learning using proven pedagogical approaches, such as the constructive alignment, scenario-based learning, etc
- will conduct an evaluation of student learning experience of the abovementioned module change, and use the results to further improve the learning task
- will engage in reflective practice to continually improve his/her teaching practice

Our initial effort towards sustaining CDIO capability of our lecturers in covered earlier by Cheah and Singh (2011). The original model, which requires that a lecturer aligns his/her training (competency) to the need of the course (curriculum) and choice of pedagogy that delivers it, is reproduced in Figure 2. This framework is initially used during our earlier effort to help newly-hired lecturers in making a paced transition from industry to academia to quickly get up to speed with using the CDIO Framework curriculum design or redesign. It is equally applicable for mentoring of academic mentor. This framework is now supported with Figure 3, which is proposed by Jamieson and Lohmann (2009) for scholarly and systematic engineering educational innovation. The framework emphasizes a continual cycle of educational practice and research; and serves as a model of continual improvement that emphasizes educational research to inform education practice that further enhances the professional development of the academic mentor. As noted by Jamieson and Lohmann

(2009), this model "would *both* continually advance the body of knowledge on engineering learning *and* result in the implementation of more effective and replicable educational innovations, with the end result being better-educated students."

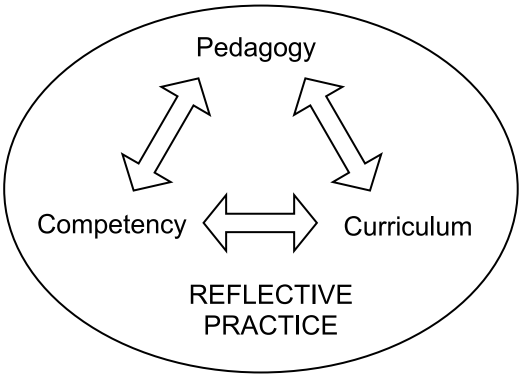

Figure 2. Alignment of Pedagogy, Curriculum and Competency (Cheah & Singh, 2011)

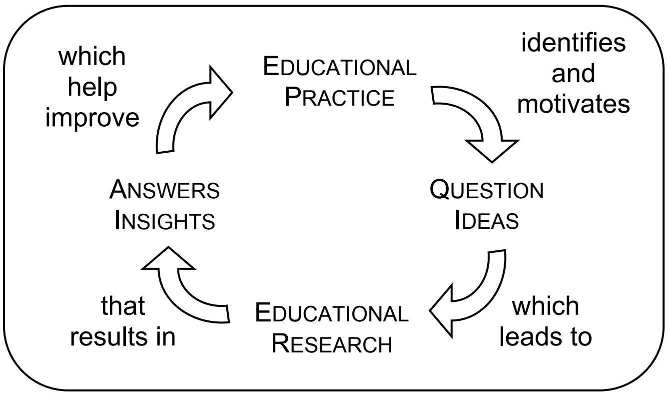

Figure 3. The Innovation Cycle of Educational Practice and Research (Jamieson & Lohmann, 2009)

In addition, we have also developed bite-size training workshops called "CDIO Clinics" (see Appendix 1) to assist lecturers to first understand the CDIO Standards and Syllabus, and to implement selected CDIO skills and Standards in his/her module(s). Each "clinic" is usually 2-3 hours, making it highly accessible to all lecturers who are already grappling with making time to attend training, and who had explicitly noted that they prefer such half-day trainings over any other formats of training.

Together these two models formed the framework for the DCHE Academic Mentor Scheme, with specific outcomes in CDIO Competence as articulated earlier. From the perspective of the mentor, the alignment of between competency, curriculum and pedagogy in Figure 2 means that he/she must possess the necessary pedagogical content knowledge needed to effectively mentor a colleague. Through reflective practice the mentor should be able to draw from a wide range of research relevant to adult learning to facilitate the learning of the mentee. From the mentee perspective, the key focus areas will be the development of CDIO competency and the relevant pedagogies to be acquired through the mentoring process. Also equally important, the mentee shall also reflect on his/her own learning arising from the mentoring encounter. Moving on to Figure 3, we henceforth emphasize the need for all teaching staff - mentors in particulars and lecturers in general - to continue to develop professionally in areas of teaching and learning. A key feature here is the use of CDIO Standards for self-evaluation at the module level (Cheah & Lee, 2015), from which a mentor alongside a lecturer can try out or innovate new approaches to engaging students. Mentors in particular are expected to continually hone their skills by staying on top of education research, adopt or adapt or innovate new approaches for his/her own teaching, and also share best practices with his/her colleagues.

An opportunity to implement the DCHE mentoring approach came when the DCHE Course Management Team decided to shift a core module entitled *Plant Safety and Loss Prevention* from Year 2 to Year 3 as part of diploma's course structure rationalization process. This coincides with SP Management's decision to adopt flipped learning and peer instruction to train students to be effective self-directed learners. The Academic Mentor trainees are encouraged to use these approaches to re-design their modules. At the same, the second author who is also the coordinator for this module had also volunteered to undergo training as Academic Mentor trainee, as she had been contemplating revamping the module for some time given that the students, while acknowledging the importance of learning the module, often complained that it is too heavy on facts and its concepts are dry and boring.

The first author, on the other hand, had been the leading figure in driving DCHE's curriculum revamping effort using CDIO, and is interested is assimilating flipped learning and peer instructions to continually improve the revamping effort. Over the past years, he had also worked with various colleagues to revamp the DCHE curriculum using CDIO. He also happens to be knowledgeable about the subject of plant safety and loss prevention from his previous industry work experience, i.e. he has the necessary pedagogical content knowledge. What remains then is for the first author to step forward to become the mentor with the second author.

From the onset, we decided that this mentoring partnership should have a structured approach to review, revise and revamp the module *Plant Safety and Loss Prevention*, but it should not be too formal, so as to accommodate our own professional development. For example, one motivation of the first author is his interest in using info-communication technologies (ICT) is supporting student learning pedagogically. Specifically, he is interested in how a case study approach based on dynamic simulation activities can be used together with flipped learning to would improve the way students learn a module heavy with facts such as *Plant Safety and Loss Prevention*. More importantly, from the point of view of sustaining CDIO capability, we will use the CDIO Framework for the module redesign. The outcome that we seek is to have an Academic Mentor well versed with using flipped learning and peer instruction to drive curriculum innovations in DCHE.

We tentatively set the mentoring duration to be 10 months, the first 3.5 months of which is devoted almost exclusively to the module evaluation and redesign, covering areas from learning outcomes, to design of learning tasks to assessment. The work done in this area is beyond the scope of this paper and is covered elsewhere (Cheah & Lee, 2015). The revised module will be introduced to students for the first time in April 2015, and during this period we will continue to monitor students' performance in learning this module. There will be 120 Year 3 students in 6 classes, i.e. 20 students per class. Unlike Loyer and Maureira (2014), we do not have the luxury of having both of us taking all 6 classes, due to manpower constraints. Instead, the first author (i.e. mentor) will take 2 classes while the second author (i.e. mentee) will take 4 classes. The plan is for the mentor and mentee to meet up at least once a fortnight to review the work done. The module will be taught over a period of approximately 4.5 months (i.e. one semester of 15 study weeks), and all assessments will be based on course-work, i.e. there is no examinations at the end of the semester. The remaining 2 months will be for the mentor and mentee to jointly evaluate the work done for improvement and implementation in the following academic year (April 2016).

Last but not least, we also decided on a simple approach to evaluate the effectiveness of the mentoring process: using student performance in the module and feedback on the module. This will ride on existing mechanism in the institution to gather input from students on their learning experience, hence do not impose additional workload on the authors. However, we do plan to convene a focus group discussion with selected students to further discuss their experience and also serve to triangulate the findings.

We believe our approach to academic mentoring offers several advantages over other models practiced elsewhere. In particular, we wish to highlight the following features:

- Since it is part of the wider SP Academic Mentor program, our lecturer are afforded an alternative pathway for academic progression. And we will continue to have experts in CDIO implementation long after the initial batch of early adopters are gone, e.g. through retirement.
- While some academic mentors may chose to 'specialize' in one or two narrower aspects of pedagogy, such as active learning (or with an even narrower focus, for example,

flipped classroom), integrated assessment, etc; our approach which is anchored in the CDIO Framework offers an academic mentor a wider scope of curriculum design and re-design which can encompass all the above areas.
- Its emphasis on pedagogical content knowledge (Figure 2) and continual improvement (Figure 3) means that both mentors and mentees alike, will be able to continually improve the DCHE curriculum even after any mentoring process had officially ended.
- The bite-size “CDIO Clinics” will be less intimidating to the mentee when he/she partners with the mentor to conduct training to fellow colleagues; and also allow more focused and in-depth learning of specific nuances of each topic, especially some of the more tacit knowledge.

We hoped that our approach offers an alternative method to mentoring reported in the literature. For far too long, there had been complaints of how, even with remarkable development of knowledge base for improving student learning, progress to-date had been slow. As noted by Korthagen et al (2006): “…the theory-practice issue seems intractable: telling new teachers what research shows about good teaching and sending them off to practice has failed to change, in any major way, what happens in our schools and universities. Neither has having teachers write behavioral objectives nor exhorting them to be reflective practitioners produced major leaps forward.”

EXPERIENCE FROM THE MENTORING PARTNERSHIP

In this section, we briefly discuss experiences from both the mentor (first author) and mentee (second author, i.e. the academic mentor trainee) as we both journeyed together in the mentoring process.

To get this partnership going smoothly, it is essential to have a matching of expectations of both parties. In order not to overload the mentee whose main focus is to quickly gain competency in using CDIO; it is mutually agreed that some aspects of the revamping effort will be done separately by mentor or mentee; while others will be jointly prepared by both. For example, the mentee will focus on converting all the module materials into suitable format for online video streaming, and the mentor will on designing learning tasks using dynamic simulation. The mentee will also rewrite the entire module's learning outcomes to better reflect higher order applications following the module's shift from Year 2 to Year 3.

A major challenge we both faced is time. Such mentoring arrangement is to be made over and above our other teaching and administrative accountabilities. There had been several instances where pre-arranged meetings which dates were mutually-agreed by both several weeks back had to be postponed due to other 'more-pressing' issues that cropped up. We therefore had to occasionally meet on ad hoc basis to touch base. Hence, from the mentor perspective, it is absolutely essential that one must possess the necessary pedagogical content knowledge to be most effective in mentoring another lecturer in a technical module such as *Plant Safety and Loss Prevention*. It allows the mentor to use the same terminology and vocabulary that immediately made sense to the mentee; and allows the mentor to provide specific feedback to the mentee without having to speak in general terms. A possible downside to this is the tendency for the mentor of trying to be 'helpful' by being too prescriptive in offering advice on how to redesign a learning task. In the case of our partnership, given the bulk of developmental work needed, we decide upfront in splitting the module re-design work between ourselves. The emphasis is to ensure that the learning tasks and assessments are matched to the intended learning outcomes, i.e. to achieve the desired constructive curriculum alignment (Biggs, 2003). Joint reviews of the mentee's work is periodically carried out, and where necessary, the mentor's own work is used as examples to illustrate how the required alignment can be attained - all using the same language and terminology that the mentee can immediately understand.

A specific challenge from the mentee perspective arises from the nature of the Academic Mentor training. It is a case of putting the cart before the horse: while one undergoes training, one is also expected to be working on a project at the same time. The 1-year academic mentor training programme entailed pedagogical training on aspects of curriculum and development, coaching and mentoring, effective learning design, assessment practices, educational research etc. While these aspects may have been covered earlier when a new lecturer first joined the teaching profession, i.e. during the Certificate of Teaching Course, the revisit of theoretical fundamentals allowed clarification of concepts while applying them to an actual project, specifically the academic mentor project, proposed and undertaken by each trainee. As explained previously, the second author, the mentee in this mentoring partnership, volunteered for the academic mentor scheme when the impetus for a major revamp of the module became clear. The mentee kicked off the project by conducting a module review and redesign via self evaluation using the CDIO standards, the effort of which is presented in a separate paper for the CDIO conference 2014.

It is noteworthy that the revamp, not unlike development of a new module, required the return to the basic curriculum alignment of the learning outcome, learning strategy and the assessment. This was also a point stressed by the mentor, and used a guiding post, in the initial plan for development. The mentee has also taken this opportunity to consult various members of DCHE course management team, as well as the co-ordinator of the academic mentor programme at the Department of Educational and Development Unit in Singapore Polytechnic, to research new developments in pedagogy (e.g. signature pedagogies) most relevant to the course and the institution.

At this point, we also looked back at the bite-size changes that were made along previously conducted annual module review and development. They included incorporation of useful resources such as videos, websites, case studies, and well as a foray into problem-based learning for part of the module. With the consolidation of teaching materials, and the consideration of module syllabus and assessment methods, both mentor and mentee agreed to the adoption of case-study approach and the structuring of teaching materials into 5 case studies over the semester. In this way, one of the takeaways of the formalisation of this academic mentor project is the establishment of a consistent pedagogical approach for the revamped module. With the framework developed, the next line of action is the development of materials for flipped learning, as well as lecture and tutorial materials based on case studies of past accidents and dynamic simulation models. As explained, the support of mentor in this partnership is also extended to his expertise in ICT and simulation softwares.

One challenge for the mentee is the grasping of new pedagogy such as flipped learning and the immediate development of associated materials for use. This is readily addressed by the mentoring partnership, where the new materials developed are shared and reviewed for relevancy, accuracy and clarity. However, the utmost challenge is the time factor. The mentee has taken on the project, in the midst of full-time teaching and administrative load, with the additional 4-hour weekly training for the academic mentor programme. From the mentee's point of view, the scope of the project is also a tad too ambitious in its scope, in terms of the depth of change and materials developed. This project deliverables can only be met, with the committed effort of both mentor and mentee, in a strategic partnership that leverage on their technical knowledge and expertise.

CONCLUSIONS

In this paper we had shared our approach to academic mentoring, with specific focus on training up an academic mentor well versed with module evaluation and redesign using the CDIO Framework. Specifically we emphasized the importance of both mentors and mentees having the necessary pedagogical content knowledge and should engage in reflective practice for continual improvement. We also discussed the motivations for both mentor and mentee as they embarked on this mentoring partnership, which allows both parties to meet their respective areas of professional development; as well as our learning experiences in this journey. We shared our approach to mentoring which we believe offers several advantages to existing models, especially in terms of its focus of career progression, effectiveness since it emphasizes pedagogical content knowledge and sustainability via continual improvement. At the time of this writing we are in the final stages of wrapping up the re-design work for the module *Plant Safety and Loss Prevention*. The re-designed module will be introduced to students for the first time in April 2015, and we hope to share the work done and report on the student learning experience in future paper(s).

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Appendix 1. Topics in DCHE CDIO Clinics

S/N	CDIO Topical Descriptions	Duration (Hrs)	Workshop Prerequisites	Primary Target Audience	Brief Information of Topics Covered	Ref CDIO Standard
A. FUNDAMENTALS OF CDIO						
1	CDIO: What it is, Why is it Needed	2.0	NIL	Course Chair	Overview of CDIO; Environmental Scan of Industry Served; Program SWOT Analysis; Drivers for Change	1
2	Understanding CDIO Standards	2.0	NIL	Course Chair	Interpretation in SP context, implications for curriculum; direction for revamping effort	2
3	Writing Learning Outcomes in Competency Terms	3.0	NIL	Course Chair, ARD Manager	Bloom's Taxonomy; graduate attributes; skills and competencies required by stakeholders	1,2
4	CDIO Skills: Teamwork and Communication	2.0	NIL	Module Coordinator	Underpinning knowledge, skill proficiency development over course duration	3,5,7
5	CDIO Skills: Personal Skill	2.0	NIL	Module Coordinator	Underpinning knowledge , Model of Thinking, Critical & Creative Thinking Tools, Multiple perspectives	3,5,7
6	CDIO Skills: Professional Skills	2.0	NIL	Module Coordinator	Underpinning knowledge: ethics & responsibility, impact of engineering on society & environment (systems thinking)	3,5,7
B. INTEGRATING CDIO INTO CURRICULUM						
1	CDIO Implementation: General Framework, Critical Success Factors	2.0	A1, A2	Course Chair, ARD Manager	Implementation Master Plan & Timeline, Program CDIO Skill Map, Change Management	1,12
2	Gap Analysis and Mapping of CDIO Skills	3.0	A4, A5	Course Chair, Module Coordinator	Existing courses' coverage; additional courses identified; Course-to-Program Outcomes	2, 3
3	Active Learning Strategies	3.0	A2, A3	Module Coordinator	Types of AL approaches, including the use of ICT, Humor, analogy, etc; Suitability to L-T-P components	8
4	Rubrics and Assessment	2.0	A3 & as needed: A4, A5, A6	Module Coordinator	Formative vs Summative Assessment, performance-based assessment; assessment for learning	11
5	Designing Integrated Curriculum	3.0	A2, B2, B4	Course Chair, Module Coordinator	Types of integrated curriculum, technical vs skill integration, integration of C-D-I-O skills, including Design Thinking	3, 4
6	Designing Integrated Learning Experience	3.0	B1, B3, B5	Course Chair, Module Coordinator	Engineering Practice (lab activities), Design-Implement Experiences (e.g. FYP), OSIP, etc; workspace needs	4,5,6,7
C. EVALUATION OF CDIO IMPLEMENTATION						
1	Conducting Survey of Student (or Graduate) Learning Experience	2.0	B5, B6	Course Chair, Module Coordinator	Course vs Module-level evaluation, questionnaire design, focus group discussions, student co-participants	12
2	Quality Assurance using CDIO Self-Evaluation	3.0	A2, B1, B2, C1	Course Chair, Module Coordinator	Evidence to demonstrate "compliance"; integration into existing quality systems (AQMS)	12
3	Sustaining CDIO Implementation: Staff Capability Building	2.0	A1, C2	Course Chair, ARD	Training needs analysis, mentoring and OJT (lab activity), writing for CDIO Conferences	9,10