EDUCATION AS COMPLEX SYSTEM: NEED FOR MORE FORWARD-LOOKING CDIO PROGRAM EVALUATION

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ABSTRACT

This paper advocates for the explicit articulation of the needs for programs to engage in external and internal scanning within an educational context, to strengthen each program's positioning in responding to changes in its operating environment in a more timely and effective manner. It noted that the 12 CDIO Core Standards, in particular Standard 1 and Standard 12, did not state explicitly the need for Program Chair to undertake such exercises. In addition, Standards 9 and 10 also did not made clear that this should be a core competency of Program Chairs. This paper suggests that Program Chairs can learn from strategic planning management in the business world, using tools such as STEEP Analysis and SWOT Analysis. STEEP is the acronym for the five drivers of change that can affect an organization and its operations, namely Social, Technological, Economic, Environmental, Political; and SWOT stands for the acronym Strengths, Weaknesses, Opportunities and Threats that the organization is facing. In addition, due to the complex nature of education, with many stakeholders often with competing demands, a tool for analysis the relationship between these stakeholders is also needed. This paper firstly provides a brief introduction strategic planning in the educational context, followed by the use of STEEP Analysis and SWOT Analysis. It then shares the use of STEEP Analysis and SWOT Analysis alongside the CDIO Self-Evaluation process by way of 2 case studies for the Diploma in Chemical Engineering (DCHE): one in introduction of chemical product design (in 2007) and another on impact of Industry 4.0 on chemical engineering education (in 2018). The paper then proceeds to discuss a key learning point from the latest review of the DCHE curriculum initiated in 2020 to enhance coverage of sustainable development, which is the need to make sense of sustainability issues. This paper further posits that today's educational system is itself a complex system and efforts towards Education for Sustainable Development needs a more systematic approach to complement the CDIO Self-Evaluation in analyzing interactions and relationships between various change drivers and key stakeholders. To this end, the paper proposes one explores the Cynefin Framework, which had been used as a tool for sense-making when analyzing complex systems in various contexts. Lastly, this paper discusses the relative merits in the CDIO Framework in formalizing the use of external and internal scanning and developing competency for Program Chair in this area.

KEYWORDS

External Scanning, SWOT, Cynefin Framework, Sustainability, Core Standards 1 and 12

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

New developments brought about by the Fourth Industrial Revolution (4IR), renewed emphasis towards sustainable development, on-going pandemic, etc; had created new demands and expectations for engineering education. Hadgraft & Kolmos (2020) had suggested that new types of engineering programs are required. In today's fast changing world, educators especially those tasked in managing programs – known in various capacities as Program Chair, Program Owner, Program Manager, etc – faced tremendous pressure to keep the programs up-to-date and remain relevant to meet key stakeholders' requirements. This term "Program Chair" will be used for this paper, as this is closest to the term "Course Chair" used in Singapore Polytechnic (SP).

CDIO Standards are a key part of the CDIO Framework, as they defined the distinguishing features of a CDIO program, by providing guidelines for educational reform, and serves as a tool for continual improvement (Crawley et al, 2014). The latest version of the standards (i.e. version 3.0) now comprises 4 optional standards in additional to the initial 12 standards, now designated as core standards (Malmqvist, et al, 2020). With regard to the 12 CDIO Core Standards, 2 stands out as being most relevant to program management: Core Standard 1 The Context, and Core Standard 12 Program Evaluation. These 2 standards set the stage for reviewing all the courses covered in a program with the aim of continual improvement. Application of these 2 standards requires the Program Chair to be well-versed with the challenges affecting the environment in which the educational institution operates in, that drives its educational objectives and outcomes.

The description for CDIO Core Standard 12 Program Evaluation, noted that:

> "*A system that evaluates programs against these twelve standards and any optional standards adopted, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement*."

This is further elaborate as follows:

> "*Program evaluation is a judgment of the overall value of a program based on evidence of a program's progress toward attaining its goals. A CDIO program should be evaluated relative to these 12 CDIO Standards and any optional standards that it has adopted. Evidence of overall program value can be collected with course evaluations, instructor reflections, entry and exit interviews, reports of external reviewers, and follow-up studies with graduates and employers. The evidence should be regularly reported back to instructors, students, program administrators, alumni, and other key stakeholders. This feedback forms the basis of decisions about the program and its plans for continuous improvement*."

From the perspective of Course Chairs, who may not be involved in strategic planning or analysis of change drivers affecting education, the use of CDIO Standard 12 may appear to be rather "inward" looking, in that it emphasize the review of other core and optional standards, i.e. how these were used to drive curricular change. Any reference to external scanning is at best implied and EXPLICIT mention of internal scanning is absent. For example, in Core Standard 2 it was mentioned that learning outcomes are to be validated by program stakeholders, and the rubrics mentioned of review by internal and external stakeholders.

Several authors from the CDIO Community did reported on the needs to engage key stakeholders in driving curriculum changes (e.g. Gunnarsson, et al, 2022; Brink, et al, 2020; Edelbro, et al, 2017; Kans, 2016) but few made explicit reference to external scanning (e.g.

Kupthasthein, 2020). There appears to be a gap in the CDIO standards that addresses academic program management.

An important point worth remembering is that educational output (in terms of its graduates) will always be lagging in responding to new demand, and time is always needed to make changes to existing curriculum, obtain faculty buy-in, develop faculty capability, develop new learning resources, etc. With students spending 3-4 years in campus learning, the industries they meant to serve will not see any such graduates until at least 4 years later. It will always be a perpetual struggle to keep up to date and respond to external changes. A more "outward looking" CDIO Standards can help to mitigate this.

This paper advocates for the explicit articulation of the needs for programs to engage in external and internal scanning within an educational context, so as to strengthen each program's positioning in responding to changes in its operating environment in a more timely and effective manner. In addition, due to the complex nature of education (Ghaffarzadegan, 2017), with many stakeholders often with competing demands, a tool for analysis the relationship between these stakeholders is also needed.

EXTERNAL AND INTERNAL SCANNING, SWOT ANALYSIS, CYNEFIN FRAMEWORK

In today's VUCA (volatile, uncertain, complex, ambiguous) world, it is of vital importance for an educational institution to stay abreast of external changes that may affect their timeliness in preparing the young for a future that cannot be clearly defined. At the same time, educational institutions are facing several challenges, including a decline in government funding (which often translated into reducing headcount), changing student demographics, and a need to compete with the emerging models of higher education (virtual university, massively open online courses, etc) while keeping the essence of a traditional comprehensive university. Various stakeholders are now demanding increased justification and documentation of program outcomes. The effectiveness of educational institutions is therefore increasingly dependent on their understanding of the external environment and their capacity to forecast and respond to the changing external landscape (Lapin, 2004). Many educational planners are turning to the process of strategic planning widely used in the business world for help.

Strategic planning can help universities maintain stability in a changing environment and respond constructively to increasing competition or external threats (Goldman & Salem, 2015). Lerner (1999) noted that the following benefits of strategic planning to universities:

- Creates a framework for determining the direction a university should take to achieve its desired future
- Provides a framework for achieving competitive advantage
- Allows all university constituencies to participate and work together towards common goals
- Allows dialogue between participants, thus improving understanding of the organization's vision, and fostering a sense of ownership of the strategic plan, and belonging to the organization
- Aligns the university with its operating environment
- Allows the university to set priorities

In the business world, tools for external scanning such as STEEP Analysis and SWOT Analysis are well known among management executives. STEEP is the acronym Social, Technological, Economic, Environmental, Political - the 5 drivers of change that can affect an

organization and its operations; and SWOT stands for the acronym Strengths, Weaknesses, Opportunities and Threats that the organization is facing. These tools, contextualized for the educational setting, would be of tremendous benefits to Program Chairs. However, many are often not familiar with them. Furthermore, CDIO Core Standards 9 and 10 also did not address the question of faculty competency in academic program management.

External Scanning in Educational Context

A key step in the strategic planning process is that of external scanning (also often known as external analysis or environmental scanning). It is the process of ongoing tracking of trends and changes in an organization's internal and external environment that may impact on its operations, especially in the future. It focuses on the interaction of events, on how trends in one area may affect trends in another. In the corporate world, environmental scanning is an integral part of an organization's strategic planning process. It involves the systematic collection and interpretation of relevant data to identify external opportunities and threats that help shape the organizations' decision-making in formulating its responses.

External scanning is equally important in the educational context. Within the CDIO leadership, it had been extensively used in the review and revision of the CDIO Standards and Syllabus themselves. In the case of CDIO Standards, the impact of external changes to the context of engineering education was one of the main driver for the need of updating (Malmqvist, Edström, & Rosén, 2020). The review of the CDIO Syllabus and its subsequent revision follows from the revised standards. The revised syllabus specifically addressed the skills and attitudes needed for sustainable development, digitalization and acceleration (Malmqvust, et al, 2022).

External scanning is wider in scope than traditional data collection educational institutions typically engage in, e.g. demographic data of students, examination results from their secondary schools, etc. Like its corporate counterpart, this is because it is based on the assumption that major impacts on the education system can come from various sources. It is more concerned with anticipating the future than describing the present. It enables educators to predict the changes in its external operating environment that has the potential to impact of education on learners (Poole, 1991). The environment within which the scanning takes place can broadly be classified into various areas: S – Social, P – Political, E – Environment, E – Economical, T – Technological, and L – Legal. Correspondingly, there are various acronyms using some or all of these areas, e.g. PEST Analysis, STEEP Analysis, and PESTLE Analysis.

While the business world has devoted a great deal of attention to environmental scanning in their strategic planning process, it is only recently that any emphasis has been placed on such practices in school settings (Pashiardis, 1996). There are many models of strategic planning, but planning models at higher educational institutions are not as well represented in the literature as are planning models for economic and industrial organizations (Ford & Miers 2008). Hatch & Pearson (1998) describes the general techniques and sources available for environmental scanning in the educational context, the advantages and disadvantages of scanning, a checklist for evaluating the quality and usefulness of documents that might be used, and a perspective on the ethics of scanning. Dolence (2004) noted while higher education has attempted to adapt and adopt various business concepts and models for use in colleges and universities, the process of adapting business models to academic culture had not been smooth. He proposes the Curriculum-Centered Strategic Planning Model (see Figure 1) which he developed specifically for higher education.

Internal Scanning and SWOT Analysis in Educational Context

Dooris, et al (2004) noted that since most institutions of higher education share a similar mission and compete for these same objectives, an essential part of strategic planning involves shaping the institution in ways that ensure mission attainment by capturing and maintaining a market niche in the quest for resources, faculty, and students. Strategic planning therefore has both external and internal faces. The outward-looking nature of external scanning is complemented by an inward looking component, with the outcomes being reviewed to chart the strategic directions for the institutions and strategic plans formulated. This is shown in Figure 2. Formulating strategic directions and plans is often carry out with the aid of SWOT Analysis, shown in Figure 3 below.

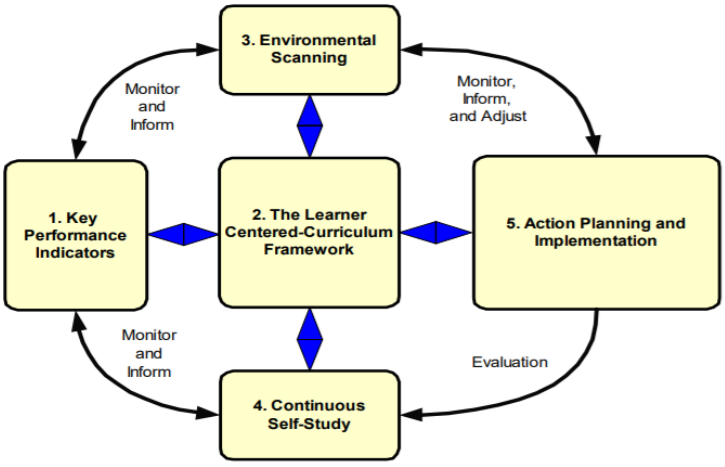

Figure 1. The Curriculum-Centered Strategic Planning Model (Dolence, 2004).

Figure 2. External and Internal Analysis and Strategic Planning (Morrison, 1993).

USE CASES: CDIO WITH EXTERNAL AND INTERNAL SCANNING

The Diploma in Chemical Engineering (DCHE) from Singapore Polytechnic (SP) had been adopting the CDIO Framework to guide its curriculum redesign process since 2006. The author, with his background in management on top of his engineering training had been using both external and internal scanning in appraising the relevancy of the DCHE curriculum when he was leading the CDIO Initiative in his school. The subsequent paragraphs in this section serve as use cases to illustrate how DCHE made use of STEEP Analysis and SWOT Analysis when it reviewed its 3-year curriculum vis-à-vis the CDIO Framework, notably Standard 12 Program Evaluation.

Figure 3. SWOT Matrix (Egger & Kent, n.a.)

Use Case No.1: Introduction of Chemical Product Design

Back in 2008, when DCHE first introduced its new curriculum revised following the adoption of CDIO, new modules related to chemical product design had been introduced (Cheah, 2010). The DCHE Course Management Team (CMT), then led by the author, had been looking for a a suitable framework to guide the curriculum redesign when it first recognized the changing paradigm in chemical engineering education that suggested the inclusion of chemical product design (Cheah, 2010). Such development promised to open up new career opportunities for chemical engineers, while at the same time, also demanded new competencies from students and graduates. The external scanning process involves studying various publications from the chemical processing industries, consulting companies such as PricewaterhouseCoopers, McKinsey, etc; as well as from academia, namely from journals such as *Education for Chemical Engineers*, and *Chemical Engineering Progress*.

The inclusion of chemical product design represents a significant change in the DCHE curriculum, which had been focused on covering competencies needed in traditional industry sectors serviced by the program, namely the oil and gas companies. All the lecturers from DCHE (the author included) are trained in the so-called 'classical' chemical engineering, where the various topics in the chemical engineering curriculum are oriented towards design of equipment and processes to serve the operations and control of chemical plants.

From a SWOT Analysis point of view, the emergence of chemical product design as a new discipline in chemical engineering can be seen as "opportunity" or "threat". The DCHE CMT saw this in the positive light, as it afforded opportunity for DCHE to distinguish itself from other similar programs offered by other polytechnics. This can be achieved by adding new modules into the DCHE curriculum and re-orienting the focus of final year student projects in DCHE. Internally, there are several "weaknesses" identified. A major one is the lack of product design capability within the ranks of DCHE lecturers. Another is the way existing final year projects are executed, which focus more in implementation and operation stages of the CDIO process. Hence, action plans need to be formulated to address the challenges posed.

The author therefore decided to engage the help of Dr. Geoff Moddridge from the Department of Chemical Engineering and Biotechnology, University of Cambridge, UK. Dr. Moggridge, along with Prof E.L. Cussler (University of Minnesota) were widely accredited with bringing chemical product design to prominence into the world of chemical engineering. To this end, he managed to bring Dr. Moggridge to Singapore to conduct a 1-week workshop on chemical

product design in 2009. Modelled after his approach, a new module was introduced into the DCHE curriculum in 2009 itself. Another module was later added, which also introduce students to the use of design thinking in chemical product design, to put more emphasis on the "conceive" stage of chemical product design. In addition, changes were made to final year capstone project in accordance with the needs of CDIO Standard 5 Design-Implement Experiences. Lastly, a basic-level design-implement experience was introduced into Year 1, Semester 1 module entitled *Introduction to Chemical Engineering*, itself a new module added based on the guidance from CDIO Standard 4 Introduction to Engineering.

Subsequent external scanning recognized the increasing importance of education for sustainable development, as the modules in the DCHE curriculum were tweaked to support the process of conceiving, designing, implementing and operating a chemical product, process or system based on project-based learning via a "project spine" in the curriculum. This eventually lead to the use of chemical product design as the basis for education for sustainable development (for more details, see Cheah, 2014).

Due to the constraint in the number of pages for the paper, we will not go into details of the processes involved. Figures 4 and 5 showed examples of selected outcomes of our STEEP Analysis and SWOT Analysis respectively.

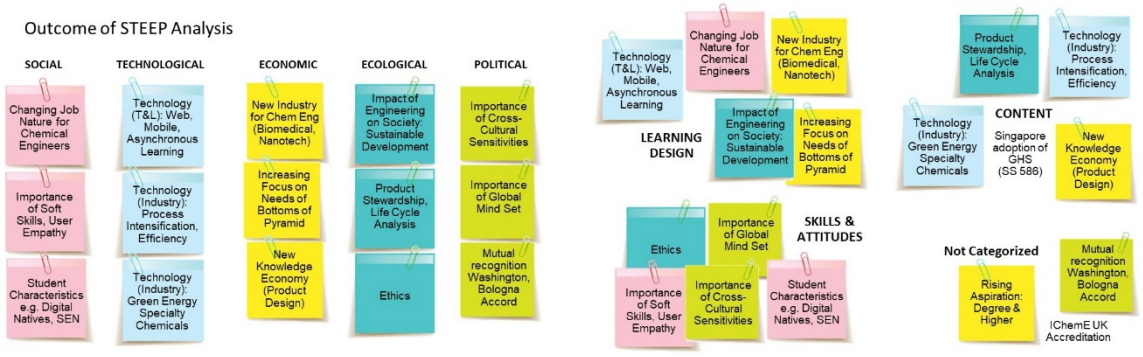

Figure 4. Use of STEEP Analysis for External Scanning and Categorization of Findings

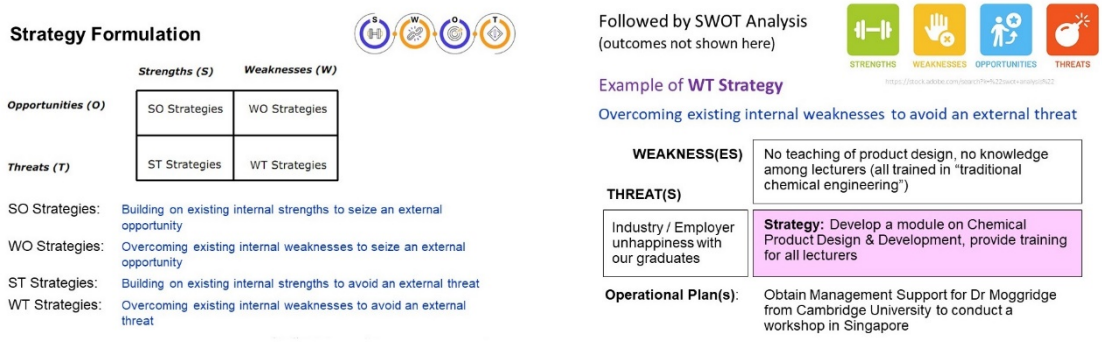

Figure 5. Use of SWOT Analysis and Strategy Formulation, with an Example shown

Use Case No.2: Integration of Digitalization arising from Industry 4.0

More recently, in response to the emergence of 4IR; the DCHE curriculum once again undergo another round of major revision. As the work done had been covered in great detail elsewhere

by Cheah & Yang (2018), only a concise summary will be provided here. Briefly, the CMT had undertaken an external scanning to ascertain what are the knowledge, skills and attitudes needed by the chemical processing industries introducing 4IR technologies into their operations. We used STEEP Analysis to identify key change drivers affecting the chemical processing industries. A key reference was the Skills Framework for the Energy and Chemicals Sector, Singapore Government's response to the challenge of 4IR. We first established that the CDIO Framework was still relevant and useful: that the CDIO Syllabus in addressing the needs of 4IR and the CDIO Standards in providing guidance to design or redesign the curriculum. We then look for areas in the DCHE curriculum that need changes. The context of review is based on the Skills Framework for the Energy and Chemicals Sector, an initiative from the Singapore Government in response to 4IR. More specifically, we used the CDIO Syllabus to identify skills and attitudes needed such as making sense of big data, data fluency in particular via data visualization, virtual collaboration and self-directed learning. The latter is a key focus area for the Singapore Skills Framework. From the self-evaluation using CDIO Standards, we identified various aspects of teaching and learning that needs enhancement. These outcomes, combined with our SWOT Analysis, helped us to prioritize areas that needed the most attention.

Figure 6 shows selected examples of broad areas of improvement needed for DCHE, as "distilled" from the outcomes of STEEP Analysis and SWOT Analysis, and presented in the form of Self-Evaluation based on the 12 CDIO Standards.

CDIO Standard 3 – Integrated Curriculum	*A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills*					
Rating from Self-Evaluation	2008:	3	2012:	4	2016:	4
Brief Summary of Selected Efforts (from 2013 to 2016) Switched to sequential diploma structure since AY13/14. Problem-based learning piloted as assignment in *Environmental Engineering* in AY13. Introduced integrated laboratory, integrated assignment & integrated mid-semester test for Year 2. 22-weeks Enhanced Internship (EI) introduced in Semester 1, Academic Year (AY) 2015. To-date, 2 runs of EI had been completed. See also Standard 5.						
Action Plans for Next 4 Years (2017 – 2020) To redesign the DCHE course structure to align to career map in the Energy & Chemicals Skills Framework (E&C SF), via a spiral curriculum, and closing gaps identified. To review EI for greater integration with the rest of DCHE curriculum. See also Standards 3 and 7 and discussion in main body of paper on approach taken.						

CDIO Standard 12 – Program Evaluation	*A system that evaluates programs against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement*					
Rating from Self-Evaluation	2008:	2	2012:	3	2016:	4
Brief Summary of Selected Efforts (from 2013 to 2016) Integrated the CDIO self-evaluation process into Academic Quality Management System (AQMS) to help with course-level review, and cascaded the review down to module level. Diploma was successfully re-accreditation by Institution of Chemical Engineers (IChemE) UK in May 2017.						
Action Plans for Next 4 Years (2017 – 2020) To obtain management approval for new spiral curriculum, to share with External Examiner, and to update IChemE UK on the changes made. To explore obtaining additional external validation of the revised curriculum, in relation to meeting E&C SF requirements.						

Figure 6. Selected Examples of Areas of Improvement from STEEP and SWOT Analyses

As can be seen from Figure 6, one of these is the introduction of a spiral curriculum for DCHE (Core Standard 3). As the Institution of Chemical Engineers UK – as the professional body that accredits the program, Figure 6 also shows that we need to engage them on the change in course structure to the spiral curriculum format (Core Standard 12). Among the many changes we implemented based on the spiral curriculum is the integration of self-directed learning (see for example, Cheah & Wong, 2022). More recently, we also revised our coverage of sustainable development based on the Singapore Polytechnic initiative to introduce a Common Core Curriculum for all diplomas, as reported in Cheah (2021).

MOVING AHEAD (1): DEALING WITH COMPLEXITY RE: SUSTAINABILITY

In the latest round of curriculum review that started in 2020, the author investigated DCHE's coverage of sustainable development (Cheah, et al, 2022; Cheah, 2021). However, for this round, it was concluded that just using the STEEP Analysis and SWOT Analysis are not adequate to help us understand the challenges of sustainability issues in light of 4IR developments. Sustainable development had already been widely acknowledged as a "wicked problem" (Rittel & Webber, 1973). The recent changes due to 4IR not only have profound influence on engineering education, but can also affect sustainability efforts in positive or negative ways. For more discussion on this, see Cheah (2021). We therefore have a case of "sustainable development meets industry 4.0", a confluence of 2 challenges each of which on their own already presented significant challenges to engineering education. The goals of 4IR, which is first and foremost to improve manufacturing productivity, are not necessarily always compatible with that for sustainable development. We need to probe deeper when studying the impact of 4IR on sustainable development.

Once again, one can turn to the business world for a framework that can be used as a sense-making tool for strategic decision making in tackling sustainability issues: the Cynefin Framework (Figure 7). The conceptual thinking of the framework was drawn from knowledge management and complexity science; and was initially developed by Kurtz & Snowden (2003) and later by Snowden & Boone (2007).

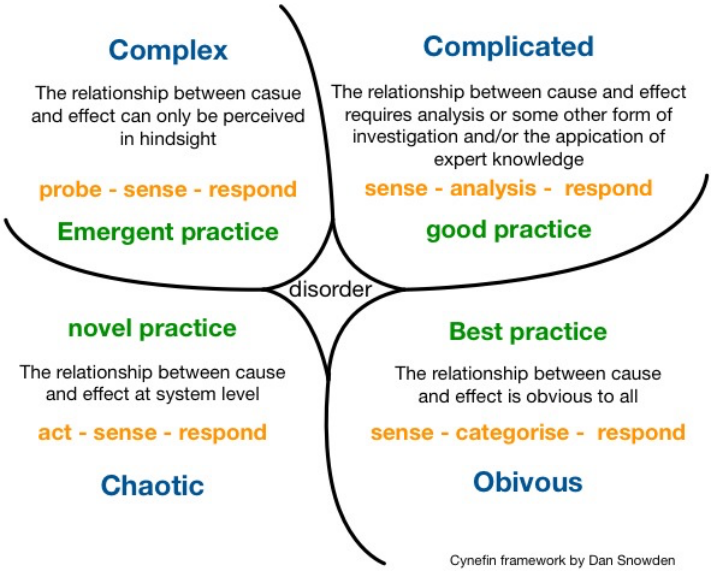

Figure 7. The Cynefin Framework

The Cynefin Framework offers a perspective of complex systems characterized with uncertainty; and concentrates on collective sense-making as a consequence of discourse. Table 1 provides explanations for the 4 categories of the Cynefin Framework – obvious, complicated, complex and chaotic – and how one can respond to each of them. The Cynefin Framework supports the use of both space and time to explicate the perspectives of different stakeholders, who populate the complex, socio-technical global contexts of the 21st century, making those perspectives visible to, and providing insights for, those involved in decision making (Hasan & Kazlauskas, 2009). Several authors had in fact used the Cynerfin Framework to investigate different aspects of sustainability issues, see for example in infrastructure design for climate adaptation (Helmrich & Chester, 2019), collaboration between partners in sustainability transitions, (Wigboldus, et al, 2019), and pedagogies in science, environment and health education (Zeyer, et al, 2019).

The Cynefin Framework had been suggested for use in educational systems (Hadgraft & Kolmos, 2020; Eskola, 2017; Gilbert, 2015). Hadgraft & Kolmos (2020) noted that "understanding of complexities derives from the dilemmas and the choices that are made in applying academic knowledge to contextual, real-world challenges". In the context of CDIO and education for sustainable development, this author will argue that the Cynefin Framework is useful to complement existing STEEP and SWOT Analyses, in helping Program Chairs making sense of challenges faced in redesigning one's curriculum for integrating sustainability issues.

Table 1. The Cynefin Framework (Kurtz & Snowden, 2003; Snowden & Boone, 2007)

S/N	Obvious	Complicated	Complex	Chaotic
Nature of problem	Obvious: once identified, it is immediately apparent	Specific expertise needed to analyze the situation	Large number of interdependent elements	No constraints, structure or discernible patterns
Cause and effect relationship	Clear patterns that occur repeatedly and predictably in the same form	Stable and existing but not immediately obvious	Not linear: dynamic and non-repeatable; constant flux and unpredictability; can only be understood retrospectively	Impossible to determine, even in retrospect, because things are continually changing at an exceptional rate
Solution / Right answer	Known and unmistakable, no rational person would disagree with your solution	Expertise – usually from different fields – are required to determine appropriate solution(s)	Elusive and not easy to ferret out; no right answers	Not recommended to jump to solution; but instead to take immediate action to steady and stabilize the environment
Practice	Best Practice exist: tried and tested formulae, recipes or templates	Good practice exists: approach can be developed and followed	Emergent: Solution emerge by interacting with the system (via small experiments) instead of analyzing or modelling it	Novel practice: objective is to move out from here into the Complex System
Suggested approach	Sense Categorize Respond	Sense Analyze Respond	Probe Sense Respond	Act Sense Respond

At the point of this writing, we have yet to make use of the Cynefin Framework. To the best knowledge of this author, use of Cynefin Framework for sustainable development is still in a nascent stage. The extant literature is still scarce. There appears to be huge potential for the use this framework for reframing diverse issues in many disciplines that are characterized by significant change and diversity (Elford, 2012). There is a good opportunity for CDIO to take the lead in addressing challenges in sustainable development by leveraging of the self-evaluation process guided by the use of CDIO Standards, supplemented by toolbox such as Cynefin Framework that analyse each sustainability issue under study.

We are looking for best practices of how it had been used in educational setting in general; and sustainable development in particular. We welcome members from the CDIO Community to explore and discuss the use of the Cynefin Framework in the context of education for sustainable development.

MOVING AHEAD (2): DOES CDIO NEED ANOTHER CORE STANDARD?

Given the points made in the above paragraphs, the last section of this paper explores the relative merits of having another CDIO core standard for external scanning. A simpler scenario would be not to have another separate standard, be it a core or optional one. This is for the simple argument to avoid proliferation of having too many standards. The need for external scanning can be made explicit in Core Standard 12, as part of continual improvement. The wording in the description for CDIO Core Standard 12 can be enhanced for example:

> "*A system that evaluates programs against these twelve standards and any optional standards adopted, via active scanning of the external and internal environment within which programs are offered to identify change drivers; and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement*."

This can then be further elaborate upon in the detailed description and rationale for Core Standard 12. Specific areas that can be affected by the outcomes of such external and internal scanning can be provided here – for example new skills and attitudes as learning outcomes (Core Standard 2), increasing use of virtual learning spaces (Core Standard 6) and online learning be it synchronously or asynchronously (Core Standard 8), etc. The author opined that there is no need to make explicit the use of tools such as STEEP Analysis, SWOT Analysis or the Cynefin Framework in the Standard.

On the other hand, argument in favor of separate standard can be made if one looked into how the existing core standards were used: not all are used by all lecturers to the same degree. Core Standards 1, 3, 6 and 12 are most applicable at the program level, mainly referenced by Program Chairs to review one's program in setting a direction for the program in response to external and internal challenges, and for continual improvement. Core Standards 2, 7, 8 and 11 in particular were applicable to most, if not all, lecturers. Lecturers responsible for learning from projects with varying levels of complexity – with different combinations of elements of conceiving, designing, implementing and operating a product, process, system or service – in a program will be most influenced by Core Standard 5. On the other hand, Core Standards 9 and 10 are which concerns faculty competency in teaching and learning, are applicable to all lecturers and often required joint evaluation with Program Chairs to identify learning gaps; as well as the School or Department's training coordinator to identify appropriate professional development programs.

On this ground, a new standard on external scanning can serve as useful addition to the existing 12 Core Standards enhance the academic management aspect under the purview of Program Chairs. This provide exclusive focus to Program Chairs on what they need to, in steering the direction a program should take. This additional standard should make explicit references to Core Standards 1, 3, 6 and 12, so that they can look at the outcomes of external scanning in a holistic manner to drive program continual improvement.

In another development related to responding to changes in higher education institutions' external operating environment, Brink, et al (2020) presented the concept of curriculum agility to help institutions respond within a shorter timeframe than traditionally the case. With its 7 principles, the need for curriculum agility also has potential to be developed into a new CDIO Standard. In fact, the principle on Stakeholder Involvement reads: "Structures and procedures at the institution for identifying and prioritizing new needs, inviting stakeholder involvement in change processes to ensure an effective process for carrying out changes". Hence, it may also make sense to explicitly include external scanning in curriculum agility.

An Alternative to Standards: Use of Toolbox

Another approach that does not require using standards would be through some kind of toolbox for Program Chairs. There can potentially be various toolboxes for different applications, for which external and internal scanning is one of them. One such toolbox can provide greater guidance to Course Chairs than a standard can, and in greater granularity. It can, using STEEP Analysis as example, suggests sources of information, methodology for data collection, organization and categorization of data to provide useful insights, etc. The toolbox can provide guidance for SWOT Analysis in terms of criteria for prioritizing action plans. Likewise, it can also provide assistance in using the Cynerfin Framework in terms of probing questions to guide the implementation of education for sustainable development.

At this juncture, the author will prefer to have a separate document for external scanning, as as compared to embedding the requirement into Core Standard 12. The possibility of synthesizing this alongside development on curriculum agility is an attractive option. The alternative of using a toolbox is also irresistible to the author. This latter option is perhaps a more viable way to proceed without introducing additional element into the curriculum agility that is already in an advanced stage in terms of its development. There can be a suite of toolboxes, each toolbox addressing one aspect of challenges in teaching and learning, such as sustainable development. The author hence opined to consult the wider CDIO community on the relative merits on how best to proceed.

CONCLUSIONS

This paper presented an argument to extend the use of external scanning as part of professional development to better equip Program Chairs in carrying out their academic management functions. This suggestion is built on the grounds that developments in an education institution's external environment is moving much faster and move towards greater complexity. Even traditional tools such as STEEP Analysis and SWOT Analysis needs to be supplemented or complemented by additional tools to help Program Chairs make sense of the intricacies of different requirements from diverse stakeholders. To this end, the Cynefin Framework is suggested. To meet this requirement, a preference is indicated for a new standard, which can also incorporate another needs identified for curriculum agility.

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