USING CDIO TO INTEGRATE GLOBAL MINDSET INTO CHEMICAL ENGINEERING CURRICULUM

Sin-Moh Cheah

S.T. Phua

Singapore Polytechnic

ABSTRACT

"Developing a Global Perspective" is a key skill as noted in CDIO Syllabus Part 4.1 External, Societal and Environmental Context. This is consistent with the Singapore Polytechnic's education outcomes, one of which is that its graduates must possess a global mindset (GM).

This paper introduces the approach undertaken by the Course Management Team (CMT) of the Diploma in Chemical Engineering (DCHE) to integrate global mindset into its curriculum, under the theme "Bringing the World to Students". This represents a pragmatic approach of firstly recognizing the fact that not all of its students will have the opportunity to take part in overseas training stints. Secondly and more importantly, the initiative demonstrates a pedagogical application of the CDIO framework that attempts to create awareness among every student enrolled in the DCHE program. The learning outcomes are to enhance students' awareness of global issues pertinent to chemical engineering and to strengthen their ability to apply chemical engineering principles learnt to respond to global needs. The revised DCHE curriculum that infuses global mindset is introduced in April 2011.

The paper details how the CMT uses its previous CDIO experience in integrating CDIO skills into DCHE curriculum to guide the present initiative. We also presented literature reviews that supported integration of global mindset into curriculum. More specifically, we explained how we unpack the attribute definition for global mindset and addressed the following questions:

- What global issues should chemical engineering education focus on?
- What skills and attitudes should chemical engineers possess?
- How can we best integrate global mindset into our curriculum?

Relevant examples are given on how global mindset is introduced to various core modules from Year 1 to Year 3. Ideas for future work are presented, along with issues and challenges encountered; both for the work done, as well as for possible future work.

(NOTE: Singapore Polytechnic uses the word "course" 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".)

Keywords: Global Mindset, Chemical Engineering, Curriculum Integration

INTRODUCTION

Singapore Polytechnic (SP) articulated its vision to be “A leading institution that prepares our students to be work ready, life ready and world ready”. In SP’s context, world ready refers to condition “where our students are skilled, confident and well prepared to respond to the demands of a fast-changing globalised environment. They will keep learning to adjust and innovate to adapt to the interconnectivity of the social and economic development of different cultures.” [1].

To achieve its vision, SP formulated four strategic goals, namely providing Holistic Education, fostering Global Orientation, Creating Learning and Social Spaces and building Capabilities. The aim is to produce the “T-shaped” graduate that is sought after in the new economy, as highlighted in the Report of the Economic Strategy Committee [2]. This is where the learning experience seeks to maximize depth of specialist knowledge as well as breadth across fields in a given course of study. Such response from SP is timely, once again reflecting the sensitivity of our senior management team to external changes affecting the organization. Indeed, the scenario in the global context is perfectly captured by Reich [3]:

> In the emerging global economy, even the most impressive of positions in the most prestigious of organizations is vulnerable to worldwide competition ... The only true competitive advantage lies in skill in solving, identifying and brokering new problems. (p.148)

As noted by Bloom [4], education improves the productivity and economic well-being of individuals, promotes technological and institutional innovation; as well as the economic performance of societies. He elaborated:

> In a globalized world, education at all levels is more important than ever. Education deficits can hinder a society in isolation, but in a globalized world these deficits can be even more detrimental to a country’s economy and development. (p.88)

To seek to develop the “T-shape” graduate in the SP context a set of six attributes have been identified as integral to all courses, these are: (3) creativity, innovation and enterprise; (4) ethics and responsibility; (5) global mindset; and (6) personal and social effectiveness. A set of attribute definitions is provided for each graduate attribute. It is further envisioned that these graduate attributes can be inculcated in students in suitable discipline core modules, general education modules, as well as co-curricular activities.

This paper focuses on the effort by the Course Management Team (CMT) of the Diploma in Chemical Engineering (DCHE) to integrate global mindset into the 3-year diploma course, leveraging on its earlier experience in implementing CDIO in its curriculum.

GLOBAL MINDSET FOR STUDENTS: INTEGRATION INTO CURRICULUM

The typical approach used by practically all educational institutions in giving students exposure to the world is “Bringing Students to the World”, through a variety of overseas programs such as student industrial training, international competition, cultural exchange, study visits, etc. The efforts involved in these programs, although by no means easy, are familiar to many faculty. This approach is indeed the preferred method of exposing students to the world, as opposed to the other way, namely that of “Bringing the World to Students”.

The disadvantages of "Bringing Students to the World" programs are familiar with most faculty. Top on the list of challenges is that of high costs, as some of these overseas destinations (such as the United Kingdom or United States) can be rather expensive. Another is that some of our diploma-level students may lacked the academic aptitude to cope with rigor of university-level project works. Other reasons include objections from parents (e.g. safety concerns, especially for females), and logistics (inland travel, accommodation), etc. Likewise, not all students will want to take part in, or qualify for, international competitions. Take the case for overseas industrial training program for DCHE for example: every semester, there are only a handful of placements for our students (less than 10%) and often "scattered" across the globe.

Most importantly, from a pedagogical perspective, such programs are plagued by issues such as difficulty of defining and measuring the learning outcomes. Often an overseas program differs from one foreign institution to another, and indeed at times depends on what had been worked out between the faculty here and his/her overseas counterpart. Implementing a common training requirement runs the risk of scuttling the program even before it got started. The words of Rubin [5] resonate well when she noted that "a more deeply integrated approach is needed to add to these measures if thorough internationalization is to occur and affect all of the students institution-wide."

Integrating global mindset into the curriculum now appears to be an emerging concern among academia now. For example, Thompson and Sterkenberg [6] noted that "… identifying methods that bring global awareness into the classroom every day may be even more critical." This is supported by Lohmann et al [7], who noted:

> Developing such global competence within the traditional engineering curriculum has been challenging. So much so that international preparation is often addressed as an add-on to the curriculum … or is relegated to short summer experiences abroad. A more integrated and immersive approach is needed and warranted if future engineers are to graduate globally competent. (p.121)

The CMT therefore decided that, in order for *all* students to acquire some degree of global mindset, it is more important to focus its efforts on the theme "Bringing the World to Students". Granted, this theme suffers from the disadvantage of really exposing students to the world; as nothing beats really being there in person and experience life in a foreign country. But given the constraints of bringing all students overseas, creating some form of exposure within the campus setting can be a reasonably acceptable compromise.

BRINGING THE WORLD TO STUDENTS – THE CDIO APPROACH

The DCHE CMT had adopted CDIO as the framework for redesigning its curriculum since 2007 (Cheah [8]). The CDIO approach had proven successful in making a positive impact on student learning various soft skills such as teamwork, communication, critical thinking, etc. The current initiative to integrate global mindset, is a natural progression consistent with CDIO Standard 3 "Integrated Curriculum" which states that a curriculum should be "designed with mutually supporting disciplinary subjects, with an explicit plan to integrate personal, interpersonal, and product and system building skills."

The challenge to do this is not new. There is obviously no more room in the already-packed DCHE curriculum to spare precious hours to cover the "fundamental building blocks for global mindset", let alone any other new knowledge such as logistics or international law. The way around this difficulty is nicely summed up by the following paragraph from a CDIO introductory brief (CDIO [9]):

> The challenge is to find innovative ways to make double duty of teaching time so that students develop a deeper working knowledge of the technical fundamentals while simultaneously learning CDIO skills. This requires changes in curricular structure, exploiting extracurricular and extra-campus learning opportunities, and development of new teaching materials. (p.3)

The DCHE response to the challenge is to embed the coverage of chosen CDIO skills in selected core modules, so that students can simultaneously acquire both technical knowledge and CDIO skills. Such learning usually takes place during the practicals (see for example, Cheah [10]) which makes use of existing laboratory time; as well as via assignments, which exploits out-of-classroom learning time (see for example, Chua etc al [11]). To integrate global mindset in students we used a range of learning components including lecture, tutorial, practical and assignments.

We conducted a new round of gap analysis for all core modules of the DCHE curriculum as part of our planned review of CDIO coverage after three years of implementation (Cheah and Sale [12]). A special focus was placed on how much of global mindset (along with other graduate attributes) we have covered. Not surprisingly, the coverage had been sparse, to say the least. This is largely due to the fact that every core module is already packed with technical contents and to some extent also included various soft skills such as teamwork, communication, critical thinking, etc. However, closer inspection of the module contents revealed a rich opportunity to introduce global mindset to students!

Here, it is noteworthy to compare the revised MIT-CDIO syllabus (Crawley et al, [13]) with that of SP's own customized CDIO syllabus, as shown in Table 1 below.

Table 1. Comparison between MIT and SP CDIO Syllabus

MIT CDIO Syllabus v2.0	SP CDIO Syllabus v2.0
4.1.6 Developing a Global Perspective The internationalization of human activity The similarities and differences in the political, social, economic, business and technical norms of various cultures International inter-enterprise and inter-governmental agreements and alliances	*4.1.4 Develop a Global Perspective* Identify the basis of cultural diversity Compare and contrast a range of cultural practices and their impact on human conduct and communication Define globalization Identify factors that contribute to globalization Identify the social, economic and environmental impact of globalization

Based on the requirements of our own CDIO syllabus, we developed the following attribute definitions for global mindset consistent with the vision that our graduates should be work-ready, life-ready and world-ready:

- Appreciate cross-cultural and global issues.
- Able to respond to social and economic development internationally.

Next, we unpacked the attribute definition for global mindset, in order to derive realistic learning outcomes for the context of polytechnic students. The CMT recognized that successful integration of global mindset into the curriculum requires faculty to be very clear on what this means in terms of specific learning outcomes.

The CMT must be able to communicate clearly to all faculty what are the cross-cultural and global issues that are relevant to chemical engineering. Likewise, the CMT needs to decide to what extent diploma-level students are expected to be able to respond to social and economic development internationally. Unpacking the attribute definition requires the CMT to address the question of what skills, knowledge and attitudes are most useful to attain and for what purpose. In the specific context of engineering education, this has been succinctly captured by Crawley et al [14]:

> What is the full set of knowledge, skills, and attitudes that engineering students should possess as they leave the university, and at what level of proficiency? (p.34)

Specifically, we set out to answer the following questions:

- What global issues should chemical engineering education focus on?
- What skills and attitudes should chemical engineers possess?
- How can we best integrate global mindset into our curriculum?

Once the first two questions are answered, answering the third question is rather straight-forward, i.e. using the "DCHE CDIO way", as shown in Figure 1. The remaining paragraphs in this section elaborate on the first two questions.

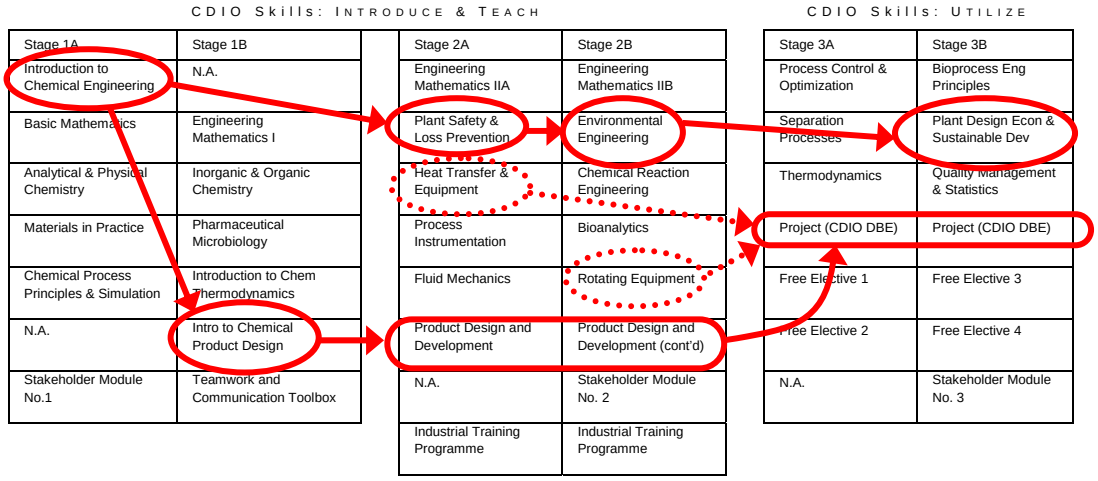

Figure 1. Model for integrating CDIO skills across DCHE curriculum

What global issues should chemical engineering education focus on?

We decided that we should clearly identify, in the context of chemical engineering, the right knowledge about global issues. There are many issues in the world today that qualify as global issues. For example, a visit to the United Nations web site showed that the UN had identified 30 global issues (www.un.org/en/globalissues) and listing, among climate change, poverty and AIDS; issues such as human rights, democracy and terrorism. Other organizations may choose to focus on selected issues only, depending on each organization's mandate or charter.

For chemical engineering, we decided to turn to the American Institute of Chemical Engineers (AIChE), who identified food, clean water, health care and energy as the 4 key global issues for which chemical engineering can play significant roles, noting that "It is in these areas and others that chemical engineering can make a significant and lasting set of contributions that will help solve these problems and improve the quality of life" [15]. Other

areas of concern to chemical engineering include pollution control, environmental protection and safety concerns, resulting from accidents at a chemical processing facility.

This immediately provides the necessary context that we need to link various chemical engineering principles to these global issues. For example, in the provision of clean water, we can directly link to several of our core modules such as *Introduction to Chemical Engineering*, *Environmental Engineering*, *Fluid Mechanics*, *Membrane Science and Technology*, and not forgetting our capstone *Final Year Project*. Applications of some chemical engineering principles in producing clean water, e.g. fluid flow calculations, filter design, membrane selection, etc are also immediately obvious.

What skills and attitudes should chemical engineers possess?

Identifying the "right" skills and attitudes to support integration of global mindset into the DCHE curriculum proved a little more challenging. Much like global issues, different organizations will define this somewhat differently. For example, the Asia Society, a leading global and pan-Asian organization working to strengthen relationships and promote understanding among the people, leaders, and institutions of the United States and Asia, used the term global competence to articulate the knowledge and skills students need in the 21st century, namely to: (1) investigate the world, (2) weigh perspectives, and (3) communicate ideas (Jackson [16]).

On the other hand, the Partnership for 21st Century Skills (www.p21.org) – a national organization that advocates for 21st century readiness for every student in the U.S. – introduced a framework (see Figure 2) to help the U.S. education system keep up by fusing the three Rs and four Cs (critical thinking and problem solving, communication, collaboration, and creativity and innovation). The framework is a blend of content knowledge, specific skills, expertise and literacies; and describes the skills, knowledge and expertise students must master to succeed in work and life.

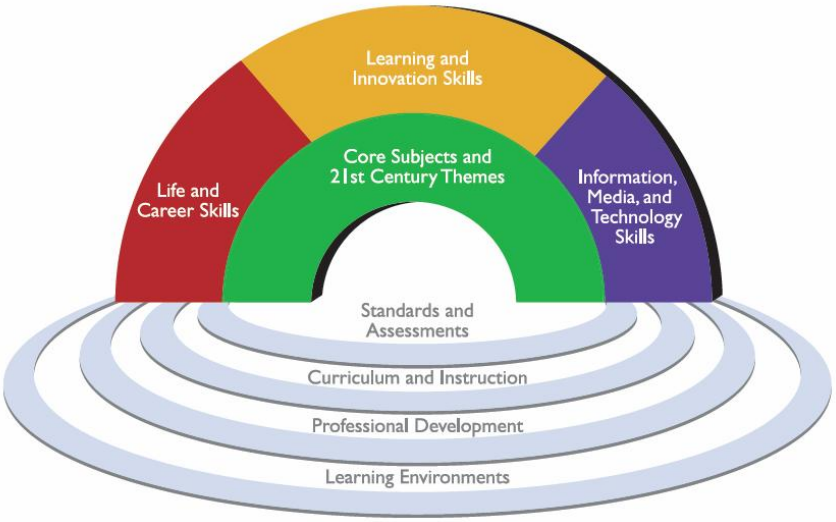

Figure 2. Framework from Partnership for 21st Century Skills

It is worth noting that regardless of which organizations, many of these skills and attitudes, such as teamwork and communication, critical thinking, displaying multiple perspective, etc has been included in the CDIO syllabus. These skills had been adequately covered in the DCHE curriculum. Other skills and attitudes, such as managing change and perseverance, appreciating foreign culture, etc will need to be introduced; once again, by carefully studying the appropriateness of the DCHE core modules to infuse them.

However, some skills, such as coping with living in a foreign environment or appreciating foreign culture, cannot be fully recreated in a realistic manner in lecture theatres, media rooms or laboratories, for the simple fact that the students are “not there”. Co-curricular activities, for all their own limitations outlined in earlier section, would be the more effective way for students to acquire such skills and develop such attitudes.

THE INTEGRATION EFFORT: WORK DONE TO DATE

As shown in Figure 1, the approach to “Bringing the World to Students” is one of progressive integration: Starting with creating awareness in Year 1, followed by reinforcement (in later part of Year 1, and throughout Year 2), ending with students demonstrating competence in Year 3. This approach is consistent with what Kajenthira and Fishbein [17] referred to as the “integrative enhancement” framework in their proposal to integrate global mindset into a curriculum.

In this approach, students in Year 1 taking the module *Introduction to Chemical Engineering* are first exposed to the globalized world of chemical engineering through awareness of the following: that the chemical industry is a global industry; chemical products are made and sold globally; and a chemical engineer is therefore a global engineer. Here various global issues relevant to chemical engineering, e.g. provision of clean water, are introduced. The module *Introduction to Chemical Product Design* further elaborated on the global nature of chemical product design by using the LifeStraw example, which is an application of chemical engineering principle of filtration.

In Year 2, each module made use of suitable examples to illustrate how chemical engineering principles pertinent to that module can be applied to tackle various global issues. One such module is *Plant Safety and Loss Prevention,* which uses various case studies on accidents around the world to discuss safety lessons learnt. For example, in discussing the Piper Alpha Disaster, students will be asked to first locate the North Sea where the incident occurred. Students are then taught the various safety principles that can be put in place to prevent future similar incidents. As another example, in the module *Chemical Reaction Engineering*, the faculty facilitated discussions among students on how biofuels can be produced via chemical reaction engineering to help address the issues of using alternative fuels to reduce our dependence of fossil fuels. This can be future contextualized with examples of Natural Fuel (from Australia) or Neste Oil (from Finland), which have operations in Singapore. Another example is in the module of Environmental Engineering, which uses a case study on South East Asian Haze to introduce the Asean Agreement on Transboundary Haze Pollution and the practices of farming in neighbouring countries that are the cause of the problem.

The module *Product Design and Development* (*PDD*), in particular, offered a rich opportunity for infusing global mindset. For example, during the ideation stage, students are encouraged to come up with ideas to tackle a given global issue. They are required to source for similar and/or competitive products around the world for comparison with their proposed product. They also need to carry out patent search. They can also consider the world-wide sources of the raw materials required, and show (e.g. during their PowerPoint presentations) the location of countries that can supply the materials and their relations to Singapore.

We also leveraged on past student *Final Year Projects* (*FYP*s), mining for suitable examples for use in various core modules. For example, one of the previous projects involved students designing and fabricating a simple membrane water filtration kit for the villagers near Medan, Indonesia. This is used as an example to demonstrate real-world application of chemical engineering in the Year 1 module *Introduction to Chemical Product Design*. Another noteworthy example, this time for the Year 2 module *Rotating Equipment*, is the overseas

community project that DCHE students executed in a developing country where they installed a hand pump using paddling action to draw water from a well for the local villagers (Ng, et al [18]).

As for Year 3, we introduced global mindset in the module *Plant Design, Economics and Sustainable Development;* whereby students need to complete a chemical process plant design project. One of the requirements of the project is considerations of plant location, labor laws and other social and economic factors.

Lastly, to address some of the skills and attitudes necessary for nurturing a global mindset (such as appreciating foreign culture, understanding of foreign laws and regulations), the DCHE CMT is also in the process of introducing a new core module in Year 3 entitled *Professional and Personal Development in Chemical Engineering*, which may incorporate the framework from the Partnership for 21st Century Skills. Part of this module will feature exercises that require students to assume that they are going overseas for further study. Students will be asked to carry out extensive review of the target country, on various matters ranging from basic information such as geographical location, climate, its people and culture; to specific information such as student visa requirements, its chemical industry and prominent companies, etc. Skills much as managing and responding to change will also be introduced. This new module will be introduced in April 2012.

THE INTEGRATION EFFORT: IDEAS FOR FUTURE WORK

We will therefore continue to integrate global into more core modules, consistent with the model shown in Figure 1. We are in particular interested in seeing our students demonstrating global mindset in their disposition. One such good candidate is obviously the *FYP* itself, besides the other modules in which global mindset is infused.

In the course of integrating global mindset into the curriculum, we learnt that often other CDIO skills can be and indeed better to be, integrated into the same study for global mindset. These skills include the other components from CDIO Syllabus Part 4.1 External, Societal and Environmental Context. These include the following:

- 4.1.1 Roles and Responsibility of Engineers
- 4.1.2 Impact of Engineering on Society
- 4.1.3 Society's Regulation of Engineering

Our coverage of global mindset in various modules, as mentioned in the previous section had been somewhat "scattered", i.e. not very well integrated. Similarly, our coverage of topics such as roles and responsibilities of chemical engineers, and the impact of chemical engineering on society and environment had been "scattered". Markos [19] had noted that: "Curriculum reform must include an integration of many disciplines that encourages students to focus on thinking from the local to the global." As such, the DCHE CMT is interested in using case-based learning whereby the same example (such as that for the Bhopal gas leak disaster) on global mindset (and other related topics above) can be repeatedly used in several related modules, with each module focusing on specific chemical engineering principles related to that module. This is because as very often several chemical engineering principles (such as fluid mechanics, heat transfer, process instrumentation) must be simultaneously applied to solve a given problem.

It may also be obvious from the previous section that most of the coverage on global mindset had centered on application of knowledge (i.e. more specifically chemical engineering principles) and not so much of skills. Despite the disadvantages mentioned earlier, we are still interested in exploring more opportunities for students to travel overseas

especially during Year 2, for community service projects during the school vacation break. Funding from related government agency (such as the Youth Expedition Project administered by the National Youth Council) can help to defray the costs of such overseas programs.

Such programs are presently conducted in a more-or-less ad hoc nature. We are now reviewing such programs with the intention of introducing a more structured approach to managing it, with more attention being paid of students' learning outcome. One of these outcomes is to deepen students' understanding of the issues faced by the community during the trip, and to return and propose as their *FYP*s possible solutions that can help the community. Granted, this approach still suffers from the challenge of scaling-up the experience for all students.

At the time of this paper, we are in the process of rolling out a comprehensive survey to our students to assess their learning experience with the curriculum that is infused with global mindset, ethics and responsibility and sustainable development. We have no quantitative data at the point. However, based on students' *FYP* presentations, we did see anecdotal evidence that some of our students were able to take into considerations global issues in their works. Some comments from students on our approach:

> *"The inclusion of Global Mindset into the DCHE course curriculum has allowed me to understand how Chemical Engineers stand in various global issues such as environmental pollution, chemical plant disaster and others. It allows us to see how we can do our part in these global issues. For example, the Bhopal incident (from modules: Chemical Reaction Engineering, and Plant Safety and Loss Prevention) challenged us to question the balance between ethnic, sustainable development and company profit, which is a common dilemma among engineers all over the world." – Mr Matthew James, Year 3 student.*
>
> *"The modules learnt throughout my 3 years of chemical engineering in polytechnics provide us a global mindset for future work and study. For example, Environmental Engineering provides us with knowledge on various treatment of waste by a chemical plant from around the world." – Mr Leo Chong Siang, Year 3 student.*
>
> *"I find that these modules help me understand further what chemical engineer is all about. Besides learning the theory, it allows me to see what is happening around the world and the standard of the job scope in the other country as compared to the local industry. Besides, the modules also allow me to understand the real effect of undesired accidents which lead to the serious outcome of the great number of deaths. Thus we will learn base on the mistake recorded in the history and not to repeat them again." – Mr Adin Sucipto, Year 3 student.*

ISSUES AND CHALLENGES

During the course of attempting to introduce global mindset into the curriculum, we encountered several issues and challenges. Some of them are briefly discussed below.

One issue that surfaced early is the students' lack of geographical knowledge about the world itself! Such geographical knowledge, as well as other knowledge such as cultural, economic, social, historical, etc is often required if an engineer is to be effectively employing his technical know-how in addressing a global issue. In other words, a technical solution offered must be appropriate for the context of the country under study, for example,

acceptable to the local population's cultural norms, viable in terms of the country economic situation, consistent with the country's social expectations, etc.

We termed the knowledge as the "fundamental building blocks of global mindset". Given the packed curriculum, it is obvious that we cannot add more modules to address these "building blocks". It is also quite impossible to do so, given the many countries in the world today. Our solution to this dilemma is to provide the necessary information in an "on-demand" manner. This approach draws inspiration from newspapers and magazines such as National Geographic that feature a separate boxed-out section that provides background information (location, people, culture) on the country featured. For example, in covering the issue of ethics and responsibility using the Bhopal tragedy as case study (in the module *Introduction to Chemical Engineering*), the location of Bhopal in India is first presented, followed by the areas contaminated by the fatal gas leak. By including such information as part of the tutorial or assignment, we avoided the demand to teach such knowledge separately in the curriculum.

We also anticipated the following challenges in the works ahead:

One is our own faculty's lack of understanding of global issues – indeed some may not even believe that global warming is real. Some faculty may also lacked real-world exposure, not having dealt with global issues in their prior work setting, or not being posted to or worked in a foreign country. They may therefore have to resort to teaching from textbook, and thus unable to personally relate to some of the issues of global concern. These faculty may be reluctant or unwilling to propose final year projects that address one or more relevant global issues. To help faculty build up competence in this area, we hope to have more of them embarking on overseas community service projects. This however, brings on a different challenge, with many faculty unwilling (some citing old age, among other things) to leave the comfort of Singapore to undertake such "hardship" overseas.

Also, in the mind of many faculty, introducing case-based learning, or other pedagogy for that matter, to integrate global mindset into the curriculum may be perceived as yet another new initiative. Faculty may see this as addition to their already-heavy workload. Hence, we need to convince them that all the changes are indeed part of the CDIO journey. In particular, we emphasized that the CDIO approach is eclectic, i.e. not grounded in any particular pedagogy, and hence the CMT will explore any approaches so long as it works, i.e. to make learning more interesting.

Lastly, is the question of whether we need to assess global mindset. It is a well-accepted fact that students' view of assessment is different from a faculty's. As noted by Ramsden [20]:

> From our student's point of view, assessment always defines the actual curriculum... Assessment sends messages about the standard and amount of work required, and what aspects of the syllabus are most important. (pp. 187-8)

The key question to be first answered is do we need an assessment for every CDIO skill in general, and global mindset in particular. If yes, the next question is how to carry out such an assessment. Suffice to say, at the moment, the CMT does not anticipate that much assessment is required for Year 1, as the purpose of integrating global mindset into the modules in this stage of study is primarily aimed at creating awareness. Some assessment may be appropriate for Year 2 modules, depending on the modules; given that the emphasis here is on linking application of chemical engineering principles in solving global issues.

The CMT expects that the situation is like to be the same for most Year 3 modules, with the possible exception of *FYP* whereby explicit requirements for assessing global mindset may be introduced into the project assessment system. Students may be assessed on their abilities to make use of what they learnt in the DCHE course to formulate viable solution(s), demonstrating due considerations for various global issues as appropriate. This will be the subject of deeper review, given the myriad of projects that we have in Year 3.

CONCLUSIONS

This paper presented the systematic approach taken by the DCHE CMT in integrating global mindset into the curriculum, using the theme "Bring the World to Students", using the same methodology that it has used in integrating various CDIO skills in past initiatives.

As the global mindset curriculum is only rolled out in April 2011, it remains to be seen how much the DCHE students' outlook can be shaped by the work described above. Indeed, it can be said that any curriculum revamp effort is to some extent an experiment. For this reason it is important to evaluate the impact of such revamp effort in terms of its impact on student learning. As noted by Sale [21]:

> While we may have a well constituted rationale for embarking on an initiative, it is essential to ascertain if the curriculum changes introduced have in fact lead to certain desired improvements in student learning outcomes. Furthermore, we may also want to know more specifically what has improved (or otherwise) and how. From this basis we can better understand how our curriculum and teaching practices are impacting at the level of student experience, and what we might subsequently do to improve teaching and learning more systemically in that educational context.

Challenges in terms of evaluation and assessment had been presented above. This is one important area that the CMT will continue to explore. During the interim, the CMT will have to devise and put in place suitable mechanisms to gather student feedback, and take corrective actions if necessary. Specific details may vary depends on the input obtained from the blogs, survey questionnaire and focus group discussions at the end of each semester.

REFERENCES

[1] SP, "Towards SP@60 (2014) – Opening Minds, Shaping Lives; The Strategic Plan of Singapore Polytechnic", 2009/2010 Edition. Singapore Polytechnic

[2] Report of the Economic Strategies Committee of Singapore, 2010.

[3] Reich, R., The Work of Nations. New York: Vintage Books, 1992.

[4] Bloom, D.E., "Education in a Globalized World", World Economics, Vol. 7, No. 4, October – December, 2006.

[5] Rubin, K., "Globalizing General Education", International Educator, Sep-Oct, 2009; pp.20-29.

[6] Thompson, R.E. and Sterkenberg, R., "Globalize Your Curriculum – A Methodology for Shaping Students for the Global Workplace", International Conference on Engineering Education, August 6-10, 2001; Oslo, Norway.

[7] Lohmann, J.R., Rollins Jr., H.A. and Hoey, J.H., "Defining, Developing and Assessing Global Competence in Engineers", European Journal of Engineering Education, Vol. 31, No. 1, 2006; pp.119-131.

[8] Cheah, S.M., "Using CDIO to Revamp the Chemical Engineering Curriculum", 5th International CDIO Conference, June 8-10, 2009; Singapore

[9] CDIO Website, "Reforming Engineering Education – The CDIO Initiative, online document available at www.cdio.org/files/cdio_brief.pdf

[10] Cheah, S.M., "Integrating CDIO Skills in a Core Chemical Engineering Module: A Case Study", 5th International CDIO Conference, June 8-10, 2009; Singapore

[11] Chua, P.H., Cheah, S.M. and Singh, M.N. "CDIO Experience for New Faculty: Integrating CDIO Skills into a Statistics Module", 7th International CDIO Conference, June 20-23, 2011; Denmark

[12] Cheah, S.M. and Sale, D., "Sustaining Curriculum Innovation: The Diploma in Chemical Engineering Experience", 6th International CDIO Conference, June 14-18, 2010; Canada.

[13] Crawley, E.F., Malmqvist, J., Lucas, W.A. and Brodeur, D.R., "The CDIO Syllabus v2.0 – An Updated Statement of Goals for Engineering Education", 7th International CDIO Conference, June 20-23, 2010; Denmark.

[14] Crawley, E., Malmqvist, J., Ostlund, S. and Brodeur, D.R., Rethinking Engineering Education. Springer: New York, 2007.

[15] AIChE, "How Can Chemical Engineers Best Impact Societal Issues?" American Institute of Chemical Engineers Centennial (1908–2008) Publication, 2008.

[16] Jackson, A., "Global Competence: The Knowledge and Skills Our Students Need", online document available at http://asiasociety.org

[17] Kajenthira, A. and Fishbein, J.B. (2010). "Enhancing Engineers' Contribution to Global Society", Proceedings of the inaugural Canadian Engineering Education Association 2010 Conference; June 7-9; Canada.

[18] Ng H.T., Sale D. and Yeo A., "CDIO as a Force for Good: A Water Sanitation and Hygiene Community Service Program in Myanmar", 6th International CDIO Conference, June 14-18, 2010; Canada.

[19] Markos K.N., "The Importance of Global Education", Journal of Student Affairs, Vol. XIX, 2010; pp.10-15.

[20] Ramsden P., Learning to Teach in Higher Education, Routledge, London, 1992.

[21] Sale D., "Rising to the Challenge of Reframing Engineering Education: Singapore Polytechnic's Experience in Implementing the CDIO Engineering Education Framework" (tentative), to be published, 2012.

Acknowledgement

The authors would like to thank Mr. Dennis Sale, Senior Education Advisor, Department of Educational Development, Singapore Polytechnic for reviewing the paper and offering his valuable advice.

Biographical Information

Sin-Moh Cheah is a chemical engineer turned academic. He is the Deputy Director in Singapore Polytechnic, overseeing various applied sciences diploma, including the Diploma in Chemical Engineering. He has lectured on various topics including chemical engineering principles, separation processes, heat transfer and equipment, and chemical reaction engineering. His current portfolios include curriculum revamp, academic coaching and mentoring, and using ICT in education. His current scholarly interests are learning pedagogy, curriculum re-design and program evaluation. He held various positions in Mobil Oil Singapore Pte Ltd (now part of ExxonMobil) prior to joining Singapore Polytechnic.

S.T. Phua is the Course Manager for the Diploma in Chemical Engineering. As Course Manager, she ensures that the all the modules contained in the course are up-to-date, and delivered using appropriate pedagogies; and assessments are aligned to the intended learning outcomes. She also oversees the day-to-day management and operation of the course, including curriculum review, student feedback, etc. She has lectured on various topics including heat transfer and equipment, quality assurance and statistics and thermodynamics.

Corresponding Author

Mr. Sin-Moh Cheah
School of Chemical & Life Sciences
Singapore Polytechnic
500 Dover Road, Singapore 139561
+65 6870 6150
smcheah@sp.edu.sg