CDIO AS A FORCE FOR GOOD – A WATER SANITATION AND HYGIENE COMMUNITY SERVICE PROJECT IN MYANMAR

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ABSTRACT

This paper presents an exciting and novel educational initiative in which key aspects of the CDIO framework are infused into community service projects to provide students with a holistic education, as well as facilitating a global perspective.

The innovation is the work of Diploma in Chemical Engineering (DCHE) of School of Chemical & Life Sciences (CLS) at Singapore Polytechnic (SP). The CDIO framework was implemented in DCHE in 2007 and has subsequently resulted in a major curriculum reframing to meet selected CDIO Standards (e.g., syllabus outcomes, integrated curriculum, integrated learning experiences and active learning).

In this paper, we will firstly document the approach and supporting pedagogy of CDIO infused community service projects (CDIOCS). CDIOCS infuses both the technical engineering content with specific CDIO skills (e.g., personal and professional skills and attributes, interpersonal skills) through conceiving, designing, implementing and operating engineering systems in real world situations. Furthermore, through CDIOCS, participating students are exposed to a range of experiences that encourage broadening their global perspectives on political, social and economic issues faced by overseas communities. It provides the experiential context for locating engineering practices not just in the technical and academic domain, but also in the environmental, social and human conduct context.

The first run of CDIOCS by DCHE involved a group of nine students led by one staff on a project on water, sanitation and hygiene (WSH) for the people of Yangon, Myanmar. The project WSH was funded by Archdiocese Crisis Coordination Team (ACCT) and conducted in collaboration with Singapore Membrane Technology Centre (SMTC) of Nanyang Technological University (NTU). Unlike typical community service projects, where students, are mainly employed in doing the actual manual tasks, CDIOCS students are fully involved in the entire process of conceiving needs, designing solutions and finally implementing and operating their prototypes.

The participating students were grouped into three teams, each in charge of water, sanitation or hygiene aspects of the project. Each team had to conduct the relevant research and apply key skills relating to identifying the water, sanitation or hygiene needs of the community and then conceive possible solutions within the constraints of the local context. Subsequently, each team proceeded to design possible solutions for the identified needs. Each team employed a systems thinking approach to assessing implications of the various solutions that they designed in order to ascertain the impact of solutions from different perceptual frames (e.g., environmental, economic, cultural, social, etc).

Teams then built prototypes of their proposed solutions, subjecting them to rigorous testing for functionality and viability in the local context. The team in charge of the water aspect of CDIOCS project WSH designed and built a simple and cost-effective three-stage water

filtration system that produces potable water from pond water. The team in charge of the sanitation aspect designed and built an economical and ingenious pit latrine that is essentially smell-free. The team in charge of the hygiene aspect designed and produced culturally sensitive hygiene posters and animation videos for the school children in Yangon.

After this preparatory work in Singapore, the students and staff went to Yangon for five days and implemented their final prototypes in the local communities, working collaboratively with local stakeholders - who subsequently take on the operation of the systems. After 3 months students and staff returned to Yangon to assess their implemented solutions and make modifications if necessary.

Secondly, we summarize the key issues that needed to be effectively addressed in setting up and managing this challenging learning experience for our students, as well as their perception of the experience and what was meaningful learning – or otherwise – for them. Finally, we offer our recommendations for future implementation improvement of CDIOCS.

KEYWORDS
CDIO, Community Service, Chemical Engineering, Water Sanitation Hygiene, Holistic Education

INTRODUCTION

Cyclone Nargis, the worst natural disaster in the recorded history of Myanmar, caused catastrophic destruction and at least 140,000 fatalities in 2008. Three of the most pressing concerns in the aftermath of Cyclone Nargis are the lack of clean drinking water, poor sanitation and hygiene practices in disaster areas like Yangon, Ayeyarwady (also known as Irrawaddy), Bago divisions, as well as Mon and Kayin states. Provision of clean drinking water, as well as promotion of proper sanitation and hygiene practices are thus of paramount importance to prevent outbreaks of communicable diseases and potential epidemics.

Figure 1: Map of Myanmar.

In 2009, faculty and students of Singapore Polytechnic (SP), teaching on the Diploma in Chemical Engineering (DCHE) of School of Chemical & Life Sciences (CLS) decided to join in the international relief effort to assist cyclone-struck villages in Yangon, Myanmar. After two preliminary visits and nine months of planning and preparation, a group of nine students led by one DCHE staff went to Yangon for five days to conduct a project on water, sanitation and hygiene (WSH).

Unlike most community service projects conducted by SP, the WSH project is a novel and interesting initiative that integrates CDIO skills to provide a holistic learning experience, with a focus on facilitating a global perspective. Such CDIO-infused community service projects are named CDIOCS. CDIOCS projects combine both the technical engineering content with specific CDIO skills (e.g., personal and professional skills and attributes, interpersonal skills) through conceiving, designing, implementing and operating engineering systems in real world situations. CDIOCS projects also provide the experiential context for locating engineering practices not just in the technical and academic domain, but more importantly in the environmental, social and human conduct context.

In this paper we firstly outline the broad pedagogic approach taken and how key CDIO skills were systematically infused into the project structure and developed over the duration of the learning experience. Secondly, we provide examples from the student project teams to illustrate key aspects of the approach and how the conceive, design and implement processes were negotiated in the local context. Finally, drawing from the student's feedback and the project outcomes, we offer our frame on some of the critical success factors in conducting such projects, as well as improvements that may be incorporated into the present format.

PEDAGOGIC APPROACH UNDERPINNING CDIOCS PROJECTS

The pedagogical approach underpinning CDIOCS projects emerged naturally from DCHE curriculum revision at SP using the CDIO Framework beginning late 2006. After around one year of preparation, a revised curriculum was rolled out in April 2008 for the Academic Year (AY) 2008. A full description of the overall approach taken at the commencement of the revamp effort and challenges encountered have been previously documented elsewhere (Cheah & Sale, 2008; Cheah, 2008; Cheah, 2009).

A major part of the curriculum revamp, apart from the critical review of the technical knowledge and skills of the programmes, was the systematic infusion of a range of CDIO skills into our course and module structures. A particular focus was on critical and creative thinking, systems thinking and managing learning (personal & professional skills and attributes), teamwork and communication (interpersonal skills) and conceiving, designing, implementing, and operating systems in the enterprise and societal context. More recently we are exploring ways to encourage students to develop the capability to appreciate different perspectives within a global context.

In terms of integrating a range of thinking skills into the technical content we modelled the infusion approach advocated by Swartz (1987). The infusion approach argues that generic process skills such as thinking are best learned through "conceptual infusion" with the subject content. This involves identifying the ingredients of good thinking - "the skills, competencies, attitudes, dispositions, and activities of the good thinker"- and designing these into the structure of the lesson content (p.125). The essential point is that the thinking processes and skills mutually develop the meaningful acquisition of knowledge to form understanding.

For our students in the CDIOCS projects, this presents a powerful vehicle for developing good thinking as the students have to solve real world engineering problems in an unfamiliar context. To be successful, they will have to use their technical knowledge and skills thoughtfully and in relation to the local context. Working in a new and unfamiliar context also provides an excellent means to extend the students communication and teamwork skills as these are fundamental to the project's success. Furthermore, as this will all occur within a different cultural and societal context, it constitutes an ideal experiential context to foster the kind of empathy and critical reflection on personal framing necessary to encourage a wider global perspective.

CDIOCS projects not only provide a real world engineering experience, but also a novel one for students and a useful one for the overseas partners. Perhaps of most significance, they constitute real opportunities for students to display transfer of learning as they are challenged to apply their knowledge and skills in new and different contexts. As McTighe & Wiggins (2002) argue:

> Transfer is our great and difficult mission because we need to put students in a position to learn far more, on their own, than they can ever learn from us. (p.44)

Having identified the key knowledge, skills and dispositions that such projects can foster, we have developed a broad, though flexible structure, to scaffold the students in their learning experience. While the students are expected to do the work and use the necessary skills to meet the project demands, it is important to monitor their progress and integrate certain pedagogic structures to support effective and efficient learning. For example, to facilitate the

conceive-design-implement-operate process, all groups of students are encouraged to follow the following broad iterative process:

1. Conduct research on the local context, both in terms of environmental conditions, resource availability, perceived needs and perspective.
2. Generate essential questions based on their research.
3. Conduct further research, gathering information relating to such questions (e.g., ethnographic and secondary sources), build understanding and reframe where necessary.
4. Design a potential prototype based on their best framing of what might work best in the context of local constraints.
5. Test prototype and conduct necessary experiments.
6. Modify prototype until viable and feasible.
7. Implement solution, evaluate and modify, etc.

In order to support this process, faculty will have to work collaboratively with students, encouraging them to think critically and creatively, as well as employ the basic concepts and tools of systems thinking. A particularly important feature of the pedagogy is the daily reviews in which students have to explicitly model their thinking and decision making in order to develop their metacognitive abilities. In this way the students are encouraged to develop the habit of systematic reflection and monitor the quality of their own thinking. The importance of good questions is central to the thinking process, both in terms of those used by faculty and also helping students to develop the capability to generate essential questions relating to what they are trying to achieve within the specific context and constraints that they have to negotiate. As McTighe and Wiggins point out:

> The best questions point to and highlight the big ideas. They serve as doorways through which learners explore the key concepts, themes, theories, issues, and problems that reside within the content, perhaps as yet unseen: it is through the process of actively "interrogating" the content through provocative questions that students deepen their understanding. (p106)

Similarly, as the world famous success coach Anthony Robins (2001) alluded, "Questions are the primary way we learn virtually everything (p.179). In the following section, examples are provided of the kind of questions that students generated as they sought to frame the problems and conceive and design solutions that would work in the local context.

THE CDIOCS PROJECTS: EXAMPLES

The nine participating students of CDIOCS project WSH were divided into three teams, each in charge of water, sanitation or hygiene aspects of the project. While the teams followed the broad approach outlined in the previous section, each project provided unique challenges that needed to be negotiated situationally.

CDIOCS PROJECT WSH – WATER

Three of the participating students took lead in the water aspect of CDIOCS project WSH with the objective of producing clean drinking water for cyclone-struck villages in Yangon. The essential questions raised which needed to be carefully addressed included:

1. What are the living conditions of local village people in Yangon?
2. How do local village people in Yangon obtain their water for drinking and other purposes like washing and bathing?

3. What are the available water filtration systems in Yangon, as well as their costs and effectiveness?

To obtain an understanding of the local context in relation to these questions, the students carried out research using internet resources and interviewed Myanmese students studying in SP. One DCHE staff also went on the first recce trip to Yangon for site visits to the villages which revealed more information on the living conditions of the Yangon community, as well as their common practice in obtaining drinking water (refer to Figures 2 and 3).

Figure 2: A typical house in villages in Yangon. The houses are usually constructed of bamboo sheets and thin planks of wood. Earthen vats in front of the houses are used to store water collected from ponds.

Figure 3: A typical pond in villages in Yangon. The local village people dig such ponds to collect rainwater. The rainwater collected is then used for drinking, washing, bathing and even agricultural uses.

Based on their research, interviews and pictures taken from the first recce trip, the students were able to develop the following frame:

1. Local village people in Yangon have very little or even no income. Most are self-subsistence, growing crops like rice and rearing animals like chickens for food, they are unable to find jobs in downtown Yangon.

2. The local village people in Yangon obtain their drinking water from rainwater collected in ponds from municipal treatment plants as it usually does not reach the villages. Water from the municipal treatment plants is also not disinfected for drinking.
3. There are water filtration systems like ceramic filters, activated carbon filters and hollow fibre membrane filters available in Yangon. A set of ceramic, activated carbon and hollow fibre membrane filters complete with casings costs US$145. Replacement filters cost US$30 each. There are also hand pumps available in Yangon at US$30 each.

Based on their findings, and through the iterative processes identified earlier, the students made the following inferences and interpretations relating to the water filtration system that they had to design and build - it must:

1. Consist of filters that are readily available in Yangon so as to ensure ease of replacement of the filters.
2. Be effective to produce clean drinking water from pond water.
3. Be sufficiently robust and easy to maintain.

To meet these key criteria, a set of ceramic, polypropylene, activated carbon and hollow fibre membrane filters complete with casings were bought in Yangon during the first recce trip and brought back to Singapore for testings by the students. A hand pump was also purchased. Upon receiving the filters, the students performed testings on the individual filters to obtain flux performance characteristics of the filters.

After characterisation of the individual filters and analyses of the characterisation data, the students proceeded to design three possible configurations of the water filtration system. The first configuration consisted of a ceramic filter followed by an activated carbon filter and finally a hollow fibre membrane filter. The second configuration consisted of a polypropylene filter, followed by activated carbon filter and finally hollow fibre membrane filter. The third configuration comprised of just polypropylene filter and hollow fibre membrane filter.

Experiments on the three configurations were conducted to test their effectiveness in producing clean drinking water. All three configurations were found to be capable of reducing turbidity of the filtered effluent to be less than 0.5NTU. However it was found that the ceramic filter in the first configuration clogged up too quickly which meant that frequent cleaning of the ceramic filter would be required. This would mean if the first configuration was installed in villages in Yangon, the village people would have more maintenance work or they would have to replace the ceramic filter more frequently.

The third configuration was not ideal too as taste and odour of the water was not removed due to the lack of the activated carbon filter. Experimental results revealed that the second configuration would be the most ideal water filtration system for installation in villages in Yangon. The second configuration was capable of producing clean drinking water, required little maintenance and had the longest lifespan.

In addition to designing and building the water filtration system, the students also carried out testings on the hand pump bought from Yangon. Hand pumps are one of the most commonly used pumps in villages in Yangon. However testings soon revealed that the hand pump was not able to deliver sufficient head to the water filtration system. As such, the students modified or replaced the hand pump.

Electricity supply to villages in Yangon is irregular, with some villages having no electricity supply; hence use of electrical pumps that will otherwise provide sufficient head for the water filtration system is thus not practical. In addition, hand pumps are the most readily available

pumps in Yangon which make replacement of parts of the hand pumps easier. This means that use of hand pumps is still the most practical in villages in Yangon.

However since the hand pump is not capable of providing sufficient head for the water filtration system, modifications of the hand pump must be performed. Instead of using hands to provide physical force for moving the water, the hand pump can be modified to a paddle pump (refer to Figure 4).

Finally after proving the functionality of their designs, the students implemented both the water filtration system and modified hand pump in villages in Yangon.

Figure 4: (Top) A Myanmese man in a village in Yangon using a hand pump to draw water from a well. (Bottom) A modified hand pump designed by the students that uses paddling action to provide physical force to move water.

CDIOCS PROJECT WSH – SANITATION

Two of the participating students worked on the sanitation aspect of CDIOCS project WSH. The essential questions generated included:

1. What is the level of sanitation in the villages in Yangon?
2. What are the sanitation systems already in use in the villages in Yangon?
3. What are some of the issues faced by the local village people in Yangon in terms of sanitation practice?

Using a similar investigatory strategy, the students identified the following features of the local context that were pertinent to a viable problem solution:

1. There is minimal sanitation practice in the villages in Yangon. Many of the local village people simply dig small holes at the back of their houses and use them as toilets.
2. Some village people in Yangon with the help from non-governmental organisations (NGOs), churches and monasteries have simple pit latrines installed (refer to Figure 5). Such pits are usually constructed near water sources like ponds where the village people obtain water for drinking and other purposes. However, there are risks of contamination of the water sources by the wastes in the pits. In addition, such pit latrines emit very bad smell due to poor ventilation.
3. There are also more advanced sanitation systems available in Yangon (refer to Figure 6). Cost of such sanitation system is approximately US$150.

Figure 5: (LHS) A typical pit latrine in villages in Yangon. The pit latrine is constructed of bamboo sheets and thin planks of wood. (RHS) Each pit is typically eight feet in depth with a woven bamboo basket in place for wastes.

Figure 6: Two covered pits behind the toilet in a church compound in Yangon. A long blue pipe leads from the toilet carrying wastes into the pits. A curved pipe that protrudes from each of the pits is used to vent out smell. It is curved to prevent rainwater from entering the pit.

From their framing of the situation, the students made the following inferences and interpretations:

1. The sanitation system to be designed and built for the local village in Yangon must be cost-effective and easily maintained. Since pit latrines are most commonly used in Yangon, the sanitation system to be designed and built will be a pit latrine too.
2. Materials of construction of the sanitation system must be easily available in Yangon.
3. The sanitation system must reduce risk of contamination of nearby water sources and be relatively smell free.

The students then proceeded to design and construct several models of the pit latrines. Based on their knowledge in fluid mechanics, the students decided to install long vertical pipes in the pit latrines to draw out smell. The students carried out testings on the model pit latrines by varying the lengths and diameters of the vertical pipes. To simulate and "see" smell, the students created smoke using mosquito coils. It was observed that as the length and diameter of the vertical pipe increased, this actually reduced the smell more effectively.

The students also assessed the practicality of their design in the Yangon context and noted that:

1. There is a limit to the diameter of the vertical pipe that can be used as the typical size of a pit latrine in villages in Yangon (three feet by three feet).
2. As length of the vertical pipe is also crucial in the effectiveness of drawing out smell from the pit latrine, greater support of the vertical pipe will be needed as the pipe length increases. As such, the typical pit latrine that is built of bamboo sheets and thin planks of wood that are commonly found in villages in Yangon will not be able to support the vertical pipes. This means that the pit latrine should be constructed using stronger materials like concrete or bricks.
3. The design of the pit latrine needs to have more openings at the top sides of the pit latrine to allow more natural light to enter. This is important as electricity supply from municipal power stations is very unstable in villages in Yangon. There are often power cuts that can last for several hours.

Subsequently, the students tested and chose an optimum diameter of two inches for the vertical pipe. Length of the vertical pipe was selected to be eight feet to ensure that it would be taller than the pit latrine of typical height six feet. They obtained permission from Singapore Red Cross Society (SRCS) and constructed a full-scale pit latrine on SRCS campsite (refer to Figure 7). Finally, the students implemented the full-scale pit latrine in Yangon (refer to Figures 8 and 9).

Figure 7: A full-scale pit latrine in SRCS campsite.

Figure 8: (Top) A Myanmese worker digging the pit for the sanitation system. (Bottom) Concrete rings that will be placed in the pit to contain wastes from the latrine. The concrete rings will minimise risks of contamination of nearby water sources like ponds.

Figure 9: (Top) Myanmese workers constructing the latrine for the sanitation system. The latrine is constructed using bricks. Bricks are more robust materials than bamboo sheets that will be able to support the long vertical ventilation pipe. (Bottom) Two pits have been constructed behind the latrine to contain the wastes. A manhole is constructed for each pit for easy human access to remove the wastes when the pit is full.

CDIOCS PROJECT WSH – HYGIENE

The other four participating students were in charge of the hygiene aspect of CDIOCS project WSH. To design a hygiene program that will be suitable for children in Yangon, they needed a better understanding of the hygiene conditions amongst village children in Yangon. There initial framing questions included:

1. What is the level of hygiene practices in Yangon?
2. What are the lacking hygiene practices in Yangon?
3. What are some ways to run an effective hygiene program?

From their subsequent research, a number of significant findings emerged, these included:

1. The level of hygiene practices amongst children in villages in Yangon is low (refer to Figure 10). Main concerns of local village people are actually having sufficient supplies of food and water rather than practising good hygiene. This means that good hygiene practices like washing hands in villages that face shortage of water supplies (especially during dry seasons) is more of a luxury than need. Even so it is important to convey and practise proper hygiene practices to prevent outbreaks of communicable diseases.

2. Children in villages in Yangon also cannot afford items like toothpaste and toothbrush. Hence, many of them resort to using unorthodox means like charcoal or branches of trees to brush their teeth.
3. Many adults also do not know how to practise good hygiene.

Figure 10: (Top and Bottom) Myanmese children living in an orphanage in Yangon drinking water using shared cups from small ceramic pots. The cups are not washed before or after drinking.

Based on these findings, the students made the following inferences and interpretations:

1. Since children are the main targets in the hygiene program, the hygiene messages to be conveyed in the hygiene program must be kept simple and easily comprehensible. Thus there will only be three hygiene messages in the hygiene program. That is, the proper way of washing hands, brushing teeth, as well as sneezing and coughing.
2. Furthermore the hygiene program must be run in an interesting manner to capture the children's attention and create lasting impression in them. As such, the hygiene program will be conducted with the aid of education materials like posters. Cute animation hygiene videos on the three hygiene messages will also be created. In addition, there will be short skits to reinforce the hygiene messages.
3. Finally, besides running the hygiene program for the children, it is also important to educate stakeholding adults (e.g., teachers in local village schools, churches or monasteries). This would make the hygiene program more effective and sustainable.

In addition, based on this framing of the situation, students proceeded to design the first draft of hygiene posters (refer to Figure 11). After the first draft, the students assessed the suitability of the posters for children in Yangon. Besides creating the hygiene posters, they also worked on the first draft of hygiene videos. One DCHE staff also went on a second recce trip to Yangon and showed the hygiene posters and videos to local Myanmese children and teachers for feedback.

From subsequent research, the students proposed the following modifications to the hygiene posters and videos.

1. Pictures that are used in the hygiene posters should preferably be Myanmese children or children of Asian descent. This is to enable the children in Yangon to better relate to the hygiene posters.
2. Instead of animated or cartoon children pictures, pictures of real children should be used. as children in Yangon are not familiar with animated pictures and may not be able to relate to such images (refer to Figure 12).
3. The hygiene video should use animal characters that the children in Yangon are familiar with (e.g. bears and chickens). It should also include light-hearted music. If voice-overs are needed, children's voices in the local language are to be used. If no narration or voice-over is used, the animations in the hygiene video must be simple, straightforward and easily understood by children in Yangon.

Figure 11: First draft of hygiene posters.

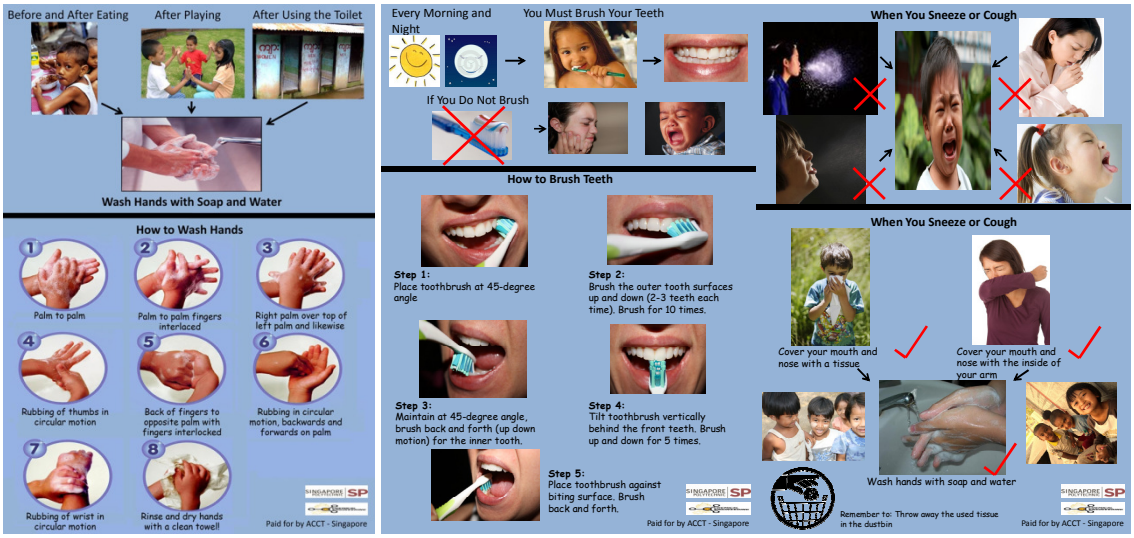

Figure 12: Final version of hygiene posters.

After designing and creating the final hygiene posters and video, the students worked on three short skits that would reinforce the hygiene messages. Finally, they implemented the hygiene program in Yangon. In total, it was run for a group of Canossa sisters, who would become teachers in local church boarding schools in Yangon, as well as for two groups of children in an orphanage and boarding school respectively.

KEY ISSUES IN SETTING UP AND MANAGING CDIOCS

A number of key issues had to be addressed in order to set up and run CDIOCS project WSH successfully. There were of course a number of logistics planning issues that had to be effectively negotiated. To achieve a good understanding of the local context prior to commencing the project, the DCHE staff leading the students went on 'recce' trips to Yangon. During these recce trips, the staff planned the appropriate food and accommodation for the students, as well as a comprehensive emergency action plan to handle situations like emergency evacuation due to riots or wars in Yangon. The staff also visited local villages in Yangon to obtain more first-hand information about the living conditions of the Yangon community in order to better guide the students when back in Singapore. In addition, the staff liaised with the local village representatives in Yangon to plan and prepare for CDIOCS project WSH.

Apart from the logistic issues, ensuring an effective learning approach, which would provide sufficient guidance for the students but at the same time not stifle their own creative or critical thinking abilities is challenging. The approach documented in this paper proved to be an effective structure in which students had the necessary scaffolding for the learning experience but could work with a high degree of creativity and self-directedness in deciding what was to be done and how. This high level of self-directness was made possible by the high level of motivation and personal discipline displayed by the students.

Facilitation of this type of learning required a wider skill set more than formal classroom teaching and required faculty to be able to work on a more egalitarian and collaborative basis with students. The importance of collective teamwork and good rapport were particularly important. During the 5-day Yangon trip, daily reviews were conducted which involved the students to reflect on their daily observations and happenings. Through their stay in Yangon and personal face-to-face interaction with the Yangon community, the students developed deeper understanding and appreciation of the local culture and way of

living. They were then able to perform better quality systems thinking in assessing the impacts of their designed solutions.

FINAL REFLECTIONS AND RECOMMENDATIONS

CDIOCS project WSH has demonstrated that CDIOCS is a powerful pedagogy that provides a real-world platform for students to relate technical knowledge to environmental, social and human conduct context, as well as to apply valuable key CDIO skills and attitudes. Running CDIOCS successfully requires both faculty and students to invest substantial amount of time, effort and even money, which gives rise to issue of sustainability of projects of such nature. As such, funding or sponsorship for CDIOCS projects have to be sought from industries or NGOs that are interested in such strategic partnership with academic institutions. Faculty who are involved in CDIOCS will have to go through appropriate leadership and facilitation training too.

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