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CDIO Initiative in Basic Sciences Courses in Diploma Chemical Engineering

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Abstract: This paper shares the experience of the Diploma in Chemical Engineering (EH110) of UiTM Bukit Besi Campus in using basic science courses to achieve the CDIO (Conceive – Design -Implement - Operate) goal of value-added engineering systems. In particular, it focuses on the Semester 1 course CHE 142 (Inorganic and Physical Chemistry) and semester 2 course CHE 143 (Organic and Analytical Chemistry). This course offers students understandings of concepts in chemistry while retaining the exciting aspects of chemistry so as to develop interest in the study of chemistry as a discipline. Topics covered are atomic structures, chemical bonding, acids and bases, redox reaction, chemical thermodynamics, chemical equilibrium and chemical kinetics. Meanwhie, in CHE 143 course, students learn to recognize and name organic functional groups. Students learn about systems to represent organic molecules, how structure affects physical properties, drawing resonance forms with proper arrow convention, organic acid-base reactions, substitution and elimination reactions and organic syntheses. Students also learn how to perform analytical techniques such as spectroscopy gas chromatography and learn how to interpret the resultant spectra and chromatograms. In this paper, experiences about teaching and learning activities have been addressed including assessment process of the courses taught in last 3 years.

Keywords: CDIO skills, Chemistry, Engineering, Standard, Sciences,

INTRODUCTION

A CDIO program is based on the principle that product, process, and system lifecycle development and deployment are the appropriate context for engineering education (Peter, 2012). The CDIO initiative was introduced to the UiTM's engineering faculty by Singapore Polytechnic in year 2012. The CDIO Initiative offers an education stressing engineering fundamentals, set in the context of the Conceiving — Designing — Implementing — Operating process, which engineers use to create systems and products. CDIO Syllabus states the outcomes of the CDIO curriculum which focuses on 4 areas of skill sets:

1. Technical Knowledge and Reasoning
2. Personal and Professional Skills and Attributes
3. Interpersonal Skills : teamwork and communication
4. Conceiving, Designing, Implementing and Operating System in the Enterprise and Societal Context.

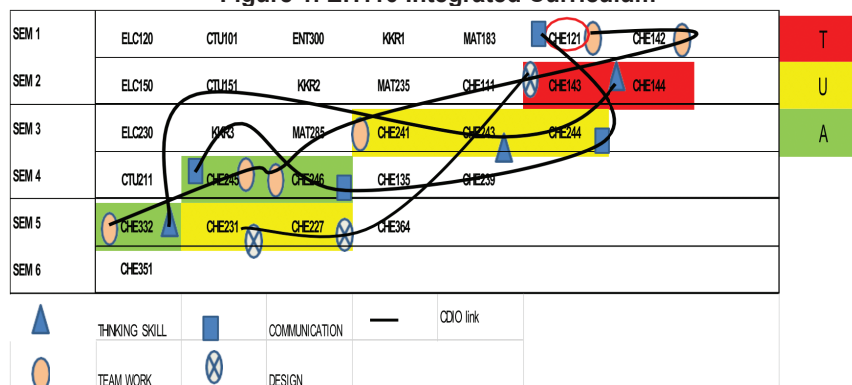
The goal from the initiative are to educate students who are able to master a deeper working knowledge of the technical fundamentals, lead in the creation and operation of new products, processes and systems, understand the importance and strategic impact of research and technological development on society and to attract and retain students in Engineering (Siegfried & Gabrielle, 2012 ; Anderews et al. 2011) Faculty of Chemical Engineering has been decided to join the CDIO initiative in the diploma curriculum level which applied of active and experiential learning, lab work, case study and project-based learning. All the skills of CDIO were integrated from semester 1 course code until semester 6 (final year) course code. Table 1 and Figure 1 show the integrated curriculum for diploma level of Chemical Engineering in UiTM.

Table 1 and Figure 1 illustrating the teaching and learning process has been structured based on CDIO syllabus. It means that CDIO skills relates through learning activities. TUA can be read as Teach Utilize/Use Assess. Teach means teaching skills and related concepts to the students. Utilize means let the students use the knowledge and achieved skills. Meanwhile, Assess means always assessing every used skills (Batdorj et al. 2018).

Table 1. Integrated curriculum in Diploma Chemical Engineering

Part	Course Code	Level	CDIO Skill
1	CHE 121	Teach	Communication, Teamwork
2	CHE 142	Utilize	Teamwork
	CHE 143	Teach	Design
	CHE 144	Teach	Thinking Skill
3	CHE 241	Utilize	Teamwork
	CHE 243	Utilize	Thinking Skill
	CHE 244	Utilize	Communication
4	CHE245	Assess	Communication, Teamwork
	CHE246	Assess	
5	CHE332	Assess	Teamwork
	CHE231	Utilize	Design
	CHE227	Utilize	Design

Figure 1. EH110 Integrated Curriculum



In order to address the CDIO spirit, two basic sciences courses are chosen to be discussed for student's learning experience.

2.1 Inorganic and Physical Chemistry Course able to :

There are three learning outcomes for this course. Upon completion of this course, students should be

1. Describe the basic principle of inorganic and physical chemistry.
2. Apply the basic principle of inorganic and physical chemistry.
3. Evaluate the inorganic and physical chemistry concept towards chemical engineering related problem.

In this course, a few activities are given to the students in order to utilize CDIO skills on teamwork. Table 2 show example scenarios for the CDIO initiative activities. All the activities emphasize on active and experiential learning methods. Meanwhile, Figure 2 shows examples of students' activities that submitted for assessment. Even though the task is simple, the given task can make the students realize that it is not enough to know the theory when it comes to solve and construct real thing (Audunsson and Manolescu, 2014).

Table 2. Example of activities in Inorganic and Physical Chemistry Course

Activity	Scenario	Objectives
1 Video on Electrolysis	You have just joined as a Process Engineer in Electroplating Sdn. Bhd. which provides quality plating and metal finishing on customer own parts for the local electrical, electronics, computer, telecommunication, optical, automotive and hardware industries. You and your team are asked by Engineering Operation Manager to make a creative video that explain clearly the basic principle of electrolysis process. This video will be presented to a group of students from UiTM that will come to visit your company. The students request to know in details about electroplating process	This activity requires you and your team to make a creative video that explain clearly about electrolysis process, factors that influence the products of electrolysis, half and overall reaction and product formed from the electroplating process. The video should include (but not limited to) the following: i. The background of the company ii. Introduction of electrolysis iii. Factors that influence the products of electrolysis iv. Explain on the process of electroplating process
2 Lab Work- Heat of Neutralization	You are working as a Product Engineer in Berjaya Sdn. Bhd. which produces Alk X. Alk X is a strong base material that used to neutralize accidentally acids spill through acid-base neutralization reaction. Reactions Alk X with acids will generate some heat. As a product engineer, you and your team are asked to construct a simple coffee cup calorimeter and measure the heat changes accompanying neutralization for weak and strong acids with Alk X	This activity requires your team to construct the calorimeter, determine heat capacity of a calorimeter and measure the heat changes accompanying neutralization for weak and strong acids with base. Upon completion of the experiment, write technical report about your team's finding
3 e-book on catalysis	You have just joined as a Process Engineer in Cal Tech Sdn. Bhd. which provides quality catalytic converter for the local automotive industries. You and your team are asked by Engineering Operation Manager to make a creative e-book that explains clearly the catalysis concept. This e-book will be presented to a group of students from UiTM that will come to visit your company. The students request to know in details about catalysis	This activity requires you and your team to make a creative e-book that explain clearly about catalysis. The e-book should include (but not limited to) the following: i. The background of the company ii. Introduction of catalysis iii. Effect of catalyst on reaction iv. Explain on the various type of catalyst and its application.

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CHEM42: Inorganic & Physical Chemistry

Activity 1: video on electrolysis

Activity 1: video on electrolysis

Photos of activity

Activity 1: video on electrolysis

Activity 1: video on electrolysis

Activity 1: video on electrolysis

Activity 1: video on electrolysis

CDIO initiative in course

CHEM42: Inorganic & Physical Chemistry

Activity 2: Lab work- Heat of Neutralization

Activity 3: K_{sp} work on catalysis

Figure 2. Examples of students' submitted activities

2.2 Organic and Analytical Chemistry Course

Upon completion of this course, the students should be capable to achieve the following course learning outcomes:

1. Apply common nomenclature system of various organic compounds structure
2. Evaluate chemical reaction mechanisms of organic compounds upon their functional group and properties

3. Analyze experimental data from an instrumental quantitative analysis

As stated in Figure 1, this course introduce and teach design skill. Therefore, there is activity has been proposed towards archieving the skill. Table 3 show an example of the activity. This kind of activity is considered as active learning which involved student interacting with course content more actively than they would in a typical educational lecture (Houseknecht, et al. 2019)

Activity	Scenario	Objectives
Lab Work - Formation of an Ester	You have just joined as a Process Engineer in Chempharm Sdn. Bhd. Your company has just received a amount of an acid and alcohol to erform an organic synthesis. As a process engineer you and your team are asked to determine the percent yield of produced ester.	This activity requires you and your team to perform an organic synthesis based on the provided chemicals. You and your team need to propose appropriate method/procedure to produce an ester based on the given chemicals and apparatus. Chemicals ethanol and ethanoic acid Apparatus Hot plate, ring stand, heating mantle, round bottom flask/distillation flask, support clamp, 20 mL pipette, magnetic stir bar, Keck clamp, connecting adapter, distillation adapter, Liebig condenser, receiving adapter, thermometer adapter, laboratory thermometer, receiving flask, in/out water hoses (Note: heating mantle with both stirrer and heater can be the optional apparatus)

Table 3. Example of activity in Organic and Analytical Chemistry Course

Since, this course at level teach of CDIO skill, the task given more to guided task. There are two set up experiment that has been proposed by students (Figure 3 (a) or Figure 3(b)). Different set up for the same objectives. The utilize level for CDIO skill in design is developed in Product Design and Development course (CHE 227) (Draman et al. 2018).

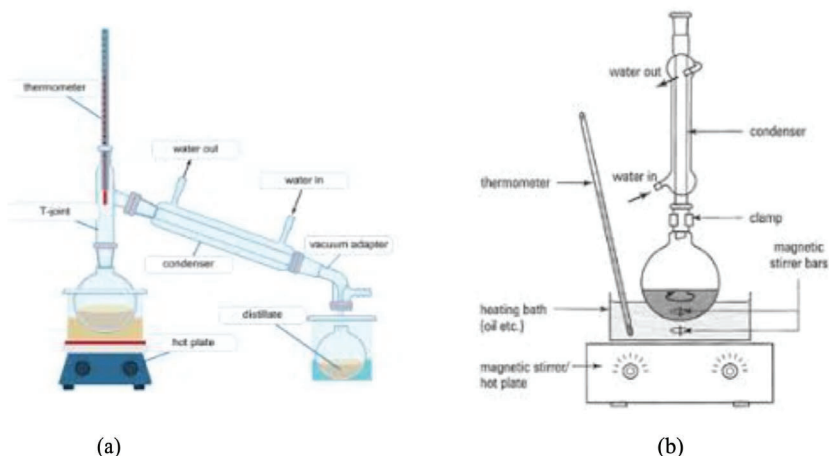


Figure 3. Example of proposed set up experiment by students

2.3 Assessment Process

There are two types of assessments which is direct assessment method and indirect assessment method (Batdorj et al. 2018). Direct assesment methods include test, final exam, laboratory work and assignment. Example of indirect assessment methods are exit survey, meeting and discussion. Figure 4 show both direct and indirect assessment methods that must be used for evaluation a program. The evaluation results are capable to improve performance of certain course's course learning outcome including these two basic siences courses in EH110 programme. Furthermore, in order to have better reflect the nature of work carried out by students, it is important that they are assessed based on different criteria relevant to the nature of the task/project (Vo et al. 2017).

CDIO intiatiave activities that carried out is align with the implementation of outcome based education (OBE) and student centred learning (SCL) curriculum that adopt since 2010. Thus, directly obey to the guideline in the Code Of Practice For Programme Accreditation (COPPA) and Programme Standard. Previuosly, the recognition for Programme Accreditation by Malaysian Qualification Agency (MQA) and now towards accreditate by the Engineering Technology Accreditation Council (ETAC) which is a delegated body by the Board of Engineers Malaysia.

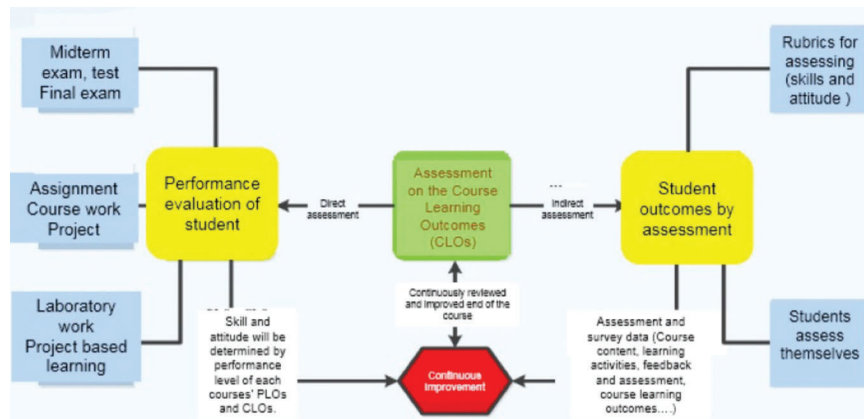


Figure 4 Assessment Process Source : Batdorj et al. 2018

CONCLUSION

The learning method through students own initiative and technology/internet based make their learning process interesting and their understanding on the topic given better. From the activity prepared, students actively participate in the learning process. They are engaged and practice the communication skill, teamwork and collaborative learning. The communication between lecturer and students become active in getting the knowledge to produce the video and other activities outcome. The students were exposed to the position of work available in the working life and working life experience. The impact from the CDIO initiative from basic sciences courses can provide an opportunity for the students to do some introductory engineering for enriching their learning experience.

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