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IMPLEMENTATION OF CDIO LABORATORY ACTIVITY IN SEPARATION PROCESSES COURSE IN CHEMICAL ENGINEERING

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ABSTRACT

This study introduces CDIO concept in Separation Processes course. It was offered for Diploma of Chemical Engineering students, UiTM Pasir Gudang. The concept was applied through LLE laboratory work, where students were given specific tasks that comply with CDIO standards. The effectiveness of CDIO implementation was evaluated through survey questions. The data available suggested that students had a fun learning experience as compared to the conventional method of teaching. They agreed that this course is the most difficult course for their level of study. They gained greater depth of knowledge as they were exposed to the real chemical engineer roles in industry through this activity. CDIO concept was proven to be successfully implemented in Separation Process. It is highly recommended that this approach to be enforced in other courses in chemical engineering program.

Keywords: separation processes; chemical engineering; project based learning; CDIO.

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1. INTRODUCTION

The chalk and talk method, which was widely used as conventional way of teaching seems to show a declining trend in terms of its effectiveness to attract students' attention in classrooms. Students nowadays have better access to reliable and attractive information as they are well equipped with electronic gadgets together with good internet connection. As a consequent, they have less interest in learning through the conventional method due to its unattractiveness and time consuming process. These phenomena resulted in failure of knowledge transfer process as students unable to fully understand the lecture. In fact, students are unable to redeliver and apply the fundamental knowledge in some circumstances and it is highly likely to happen among engineering students. They also lack in good communication and technical report writing skills where both skills are of utmost important for engineers. To curb this issue, activities in classroom, especially for engineering courses should be conducted frequently and interestingly while the focus should be student centered rather than lecturer centered.

Apart from fundamental knowledge in their respective field, the Ministry of Higher Education Malaysia also pointed out the importance of having good soft skills among graduates. Graduates especially from engineering background must be able to absorb knowledge as well as able to translate the knowledge gained into design and work. The introduction of Conceive, Design, Implementation and Operate (CDIO) concept in engineering education is an improvised teaching and learning method in classrooms through relevant activities. This process allows students to implement their knowledge besides improving their skills to serve the ever increasing needs of professional engineers. Furthermore, the Institute of Chemical Engineering (IChemE) emphasized that the chemical engineering education should stimulate and develop student's talents with a good chemical engineering program. Therefore, Massachusetts Institute of Technology (MIT) and few universities in Sweden have outlined CDIO framework, consisting 4 parts syllabus, 13 skill sets and 12 standards.

This well-structured framework focuses on student-centered learning by designing an outcome-based curriculum that utilizes active learning to promote skills in conceiving, designing, implementing and operating a product or systems using a life-cycles approach together with soft skills. The skills developed along the process include teamwork,

communication, various thinking skills and others. As mentioned by [7-10], teaching through CDIO approach is contextual that should reflect real world environment. This learning concept of CDIO was nearly similar to problem based learning (PBL), which stimulates problem solving thinking among students [1]. However, to the best of our knowledge, reports on the application of CDIO concept in students' laboratory work scarce.

The key objective of chemical engineering education is to synthesize subjects into designing system, component, process or experiments [2]. The introduction of CDIO model in Chemical Engineering can meet the increasing demand among employers for graduate who possess not only technical skills, but wide range of soft skills or higher order skills including communication, presentation, teamwork and leadership [3]. The present study was conducted to evaluate the effectiveness of CDIO model in students' laboratory work of chemical engineering education. The laboratory experiment used in this study was Liquid-liquid Extraction (LLE), known to be a component in Separation Processes course's syllabus for Diploma in Chemical Engineering program in UiTM Pasir Gudang.

2. METHODOLOGY

2.1. CDIO Activity in Liquid-Liquid Extraction (LLE) Experiment

CDIO concept was incorporated in Liquid-Liquid Extraction (LLE) experiment, which was a component in Separation Processes Course's syllabus for academic session December 2016-April 2017. This course was taken by 191 students during their third year of study in Diploma of Chemical Engineering. Instructions and guidelines for LLE experiment were designed based on CDIO framework and the experiment was conducted at a pilot plant in Faculty of Chemical Engineering, UiTM Pasir Gudang.

Table 1. Number of student enrolled and valid response

Subject	Number of response
Number of student enroll in this course	191
Number of student conducted LLE lab (CDIO)	171
Number of responses for post experiment	91
Number of valid responses for post experiment	87

The total number of students took part in this study is presented in Table 1. However, based on the table, the total number of response for each survey varies and only valid responses will be counted throughout this study. Considering CDIO syllabus, the selection of topics must comprise personal and professional skills, attributes and interpersonal skills as suggested by [4]. The topic and skills obtainable is presented in Table 2.

Table 2. Topics as suggested by [4]

Skills	Topic
Personal and professional skills and attributes	Engineering reasoning and problem solving; experimentation and knowledge discovery, system thinking, personal skills and attributes, professional skills and attributes
Interpersonal skills	Teamwork; communications

2.2. Group Distribution

Students as respondents to the survey were divided into groups of 12, where they were required to work as a team. The groups were divided according to their academic performance in the previous academic session where each group consists of weak, average and good students. To enhance their interpersonal skills, each group has appointed one member among themselves to serve different roles; manager, safety officer, process engineer and senior technician. These roles were chosen due to the importance of its existence in a chemical processing plant. As their first assignment, they were required to select a leader to allow the experimental works to be carried out efficiently and effectively. Good interpersonal skills must be shown by the manager as the person must delegate tasks among the team members. Theoretically, the characters of the respondents are highly dependent on their specific roles. The manager must be able to identify special characters of each team member to properly delegate tasks among the team members as suggested in Table 3.

Table 3. Roles and its specific tasks

Roles	Tasks
Managers	1. Distribute roles to each team members. 2. To ensure the smoothness of the overall process. 3. Responsible in submission of the final memo at a given time to the CEO (Lecturers)
Safety Officer	1. To ensure all necessary Personal Protective Equipment (PPE) to be worn by every members. 2. To ensure chemicals to be handled properly. 3. To prepare and implement Site Safety and Health Plan. 4. Aware of active and developing situations at all time.
Process Engineer	1. Thoroughly understand and analyse critically the overall process. 2. To prepare Process Flow Diagram (PFD) and explain the process to each members. 3. In occurrence of any problems, please solve them accordingly.
Senior Technician	1. Understand the explanation provided by the Process Engineer. 2. To operate the unit accordingly. 3. In occurrence of any problems, please provide assistance to solve them.

Once this process completed, they were given a situation as the instruction in order to conduct the LLE experiment as follows.

"You have just joined Maju Jaya Ltd; a company that purifies acetone from acetone-water mixture using toluene as solvent. For the first task, you and your team is required to operate a Liquid-Liquid Extraction (LLE) column with a recovery unit. Upon completion of this task, you need to prepare a report. Refer to the theory given as guidance".

Each member in a group is responsible to take on the assigned role, where they need to understand and must deliver the given tasks. The laboratory session is allowed to be conducted once they are well prepared to run the experiment with minimal supervision. Students are expected to be able to apply and relate fundamental knowledge of chemical

engineering that they have gained throughout their two years of study.

Once they completed the experiment, they are required to present their work to the CEO, which played by the lecturer via an oral presentation. Questions will be asked according to their roles and some questions were randomly given to any members of the group to verify their involvement and understanding in the experimental work. As a knowledgeable person, the CEO will pointed out their wrongdoings during the experiment (if any) and they need to defend themselves. The process was purposely carried out under a stressful condition to test the students' limit to work under pressure. They were assessed through this process and marks were given based on the oral presentation. Also, respondents will be evaluated on scale 1 to 10 based on these criteria; work distribution, technical report, safety performance, clean-up as well as pre-experiment survey/post-experiment survey. Online pre and post laboratory experiments surveys were carried out at the beginning and end of the course to evaluate the effectiveness of CDIO model implementation in LLE laboratory work.

3. RESULTS AND DISCUSSION

Implementation of CDIO concept was carried out via one course at a time as it is highly unlikely to change overall program structure at once without knowing the effectiveness this new teaching concept. Hence, this study applies CDIO concept specifically in Separation Processes as it incorporates multiple fundamental chemical engineering knowledge in this course. The course supports the CDIO elements as it consists of a laboratory work involved for Liquid-Liquid Extraction (LLE) topic, where students able to experience real working environment just like engineers do. To be a proficient engineer, students need to equip themselves with professional skills such as critical thinking, problem solving and interpersonal skills. These are conventional skills heavily gravitated towards content and knowledge acquisition [4].

In this study, students are required to accomplish few major tasks; perform pre-laboratory experiments, perform experimental works and oral presentation. These tasks demanded their higher order thinking skills, interpersonal skills, knowledge understanding and learning quality. After the laboratory session, students produced a detail technical report. Evidently, it

was found that chemical engineering students have poor technical report writing skills. Since this course was taken by students who were in their third year of study, they should have an excellent fundamental knowledge in chemical engineering in order to conduct the CDIO incorporated LLE experiment. Besides Separation Processes, there are four other main courses taken by them during the current academic session, including heat transfer and equipment, separation processes, plant safety and occupational health, process control and instrumentation. Students have shown impressive presentation skills during their oral presentation and able to answer questions by linking the fundamental knowledge with their hands on experience.

Next, students answered an online post experiment survey and the data collected is presented in Table 4 and Fig. 1. Questions were divided into two sections namely individual assessments and course assessments. Questions numbered 1, 2, 7 and 9 are individual assessments while questions numbered 3, 4, 5, 6 and 10 assessed the course. The respondents need to answer based on the following scale; 1 (strongly disagree), 2 (disagree), 3 (mixed feeling), 4 (agree) and 5 (strongly agreed).

Table 4. Survey questions for CDIO implementation in separation processes

Question	Mean	Individual /Course Assessment
1. Your interest in this course.	3.82 ± 0.81	Individual
2. Expected course relevancy in preparing you to be an engineer.	4.03 ± 0.81	Individual
3. Expected difficulty level of this course.	4.05± 0.85	Course
4. Ability to define and explain the concept of mass transfer.	3.60 ± 0.83	Course
5. Ability to identify and differentiate between extract and raffinate phases as well as between solute, carrier and solvent.	3.76 ± 0.86	Course
6. Level of understanding of fundamental concepts for the	3.63 ± 0.82	Course

	respective separation processes.		
7.	Fun learning experience.	3.94 ± 0.97	Individual
8.	Do you think this learning method helped you to develop new skills that you did not acquire through the conventional learning method?	3.87 ± 0.82	Course
9.	Do you think you can gain more/deeper knowledge through this learning experience?	3.99 ± 0.84	Individual
10.	Will you recommend this learning method to other students?	3.91 ± 0.9	Course

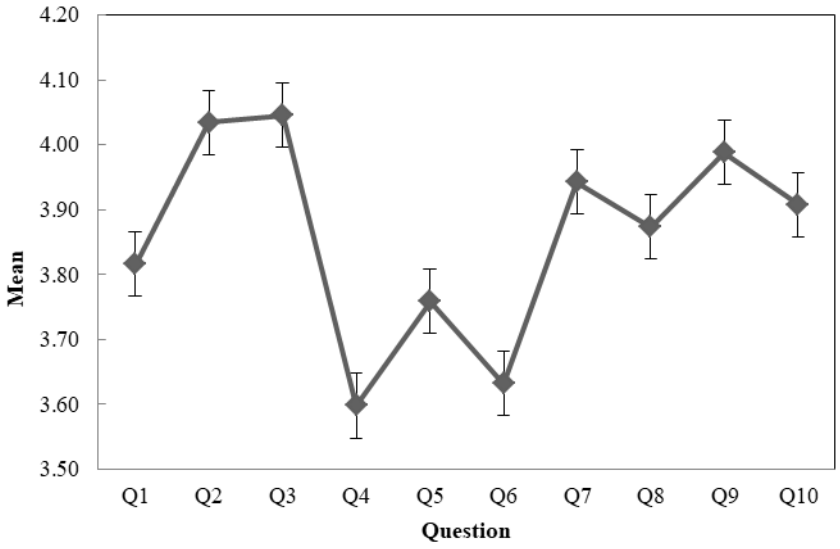

Fig.1. Mean results for question 1 to 10

Based on Fig. 1, Question 3 showed the highest mean value (4.05± 0.85) as compared to the others. Majority of the students expected that this course is the most difficult course in Chemical Engineering program. Though students agreed that this course is difficult, but a high mean value for Question 2 (4.03 ± 0.81) reveals that respondents acknowledged the importance of this course in preparing themselves to be a chemical engineer. This is due to the fact that, respondents could obtain greater depth of knowledge through CDIO activities as well as able to experience a real working environment. Along this process, students were able to self-gain the knowledge as they applied the concept of implementation and operate.

The lowest mean value (3.60 ± 0.83) was found in Question 4, which concern the student's

ability to define and comprehend the concept of mass transfer. This is the fundamental concept in separation processes. It can be seen that students were unable to relate the basic knowledge of mass transfer in LLE operation process at satisfactory level. In other words, students tend to merely memorize the meaning of mass transfer but have the difficulty to relate this concept while conducting the experimental works. Nevertheless, they able to describe basic terms relating to LLE operation such as extract, raffinate, solute, solvent and carrier. This situation was proven via Question 5 as the recorded mean value was slightly higher (3.76 ± 0.86) as compared to Question 4. However, declining mean value (3.63 ± 0.82) was obtained in Question 6 where it tested their level of understanding on fundamental concepts. It is highly possible that low mean values were recorded for these questions due to the application of conventional teaching method when delivering the fundamental concepts in classrooms. As CDIO concept was solely used in their experimental works, the results between these two teaching method differs significantly.

The CDIO activities in this course had proven that students can develop new skills, which are almost impossible to be obtained through the conventional learning method. This phenomenon was proven by the high mean value (3.87 ± 0.82) for Question 8. Besides, students recognized that the implementation of CDIO concept in their course has yielded a fun learning experience for them as asked in Question 7.

On the other hand, Question 9 showed a high mean value (3.99 ± 0.84). This question inquired their knowledge level after conducting the experiment. This value affirmed that CDIO implementation in this LLE experiment has a great potential in increasing students' level of knowledge. Self-direct learning concept was applied in this study, as suggested by [5]. This concept was adopted as the students were given a scenario as stated in section 2.2. Through the instructions, the self-direct learning questions were triggered and this factor has contributed to the recorded results. Students realized that they have obtained greater depth of knowledge as they able to link the knowledge they gained classrooms with their experience either via hands on as well as via visual. Additionally, it is also claimed by [6] that a good working environment able to help students in self-direct learning. Via this method, students able to utilize the knowledge they gained in classrooms to complete the task by working in a

harmonious group.

Lastly, most of students agreed that the CDIO implementation should be recommended to other courses (Question 10), at mean value 3.91 ± 0.9).

4. CONCLUSION

The work of utilizing CDIO concept in Diploma of Chemical Engineering is a breakthrough and more activities need to be developed to improve student's motivation and results in the course taken. The integrated CDIO framework in chemical engineering needs to be expanded to meet future demand. It can be concluded that the introduction of CDIO in Separation Process able to improve student's interest and performances as well as their level of knowledge. Activities introduced in this course were designed to meet CDIO approach where students can prepare themselves to be chemical engineers as they acted as one. Based on 10 questions given, the implementation of CDIO in Separation Processes was assessed. Even though students found out that this subject is the most difficult subject in chemical engineering, the implementation of CDIO has successfully created fun learning experience and at the same time their knowledge in Chemical Engineering widens. The implementation of CDIO should be further implemented on other courses for the benefit of the students.

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