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Delivery and Assessment Method of Bachelor of Chemical Engineering (Environment) Programme during the Covid-19 Pandemic

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Abstract— As the Coronavirus disease was declared by the World Health Organization, the Government of Malaysia enforced a Movement Control Order (MCO) starting on March 18, 2020 to break the chain of Covid-19. Educational institutions including schools and higher education have had to close due to the Covid-19 pandemic. As one of the engineering programmes at UiTM Cawangan Pulau Pinang, Bachelor of Chemical Engineering Programme (EH225) has reviewed the delivery and assessment method to maintain the continuity of curriculum structures by the implementation of Open Distance Learning. This paper reviews the implementation of teaching delivery and assessment methods specifically for EH225 before and during MCO. The transition method needs to cater to all types of assessment including general courses, laboratory, capstones project especially final year projects and integrated design projects. Since the outcomes of the programmes cannot be compromised, setting an attainable benchmark aligns with expected learning needs that should be considered. In addition, the shift in the delivery and assessment associated with modern technology and online platforms promote a technology-enhanced learning approach to facilitate the improvement of the programmes' curriculum.

Keywords— Chemical Engineering, delivery, assessment, Covid-19 Pandemic, Outcomes.

I. Introduction

Bachelor of Chemical Engineering (Environment) with Honours (EH225) programme has been designed based on chemical disciplines majoring in chemical engineering and minoring in environmental engineering. In addition, several broader non-engineering subjects such as mathematics and computing, management and entrepreneurship, communication skills, humanities and ethics, and co-curriculum are also included in the course structures.

The programme structure and course contents of EH225 are in line with the Engineering Accreditation Council (EAC) requirements, which is designed with a minimum of 90 credit hours of engineering courses offered over four (4) years. The remaining credit hours are accumulated from the university requirement and co-curriculum courses with a minimum total of 135 credit hours for the EH225 programme as stipulated in the EAC manual 2020.

In response to the Movement Control Order (MCO) due to the Covid-19 (Coronavirus) pandemic announced by the Prime Minister on March 16, 2020 (Shah et al., 2020), Faculty of Chemical Engineering UiTM Cawangan Pulau Pinang had implemented comprehensive online teaching and learning. The commencement of Open Distance Learning (ODL) for Semester II 2019/2020 started on 13 April 2020 and lasted until 21st July 2020. The implementation of teaching and learning has three (3) main sections:

- Online Teaching and Learning Delivery
- Online Teaching and Learning Assessment
- Amanah Tugas Pensyarah (ATP)

Details of guideline to the lecturers can be found in the Garis Panduan Pelaksanaan Aktiviti Pengajaran dan Pembelajaran, Pentaksiran dan Penilaian bagi Pengurus Utama (PU) dan Pengurus Pelaksana (PP) di UiTM Cawangan Pulau Pinang (Faculty of Chemical Engineering, 2020). In this paper, we focused on the two main sections: Teaching and Learning Delivery and Assessment.

II. Implementation of Programme Delivery

A. Delivery teaching method before MCO

The Programme Outcomes are aligned to Outcome-Based Education which consists of three domains of Bloom's Taxonomy. These domains comprise of cognitive, psychomotor and affective elements. Different types of assessments have been designed with high consideration of their appropriateness covering the three domains of Bloom Taxonomy. EH225 programme adopts a multi-model delivery approach of educational activities related to the particular PO statements. Detailed programme deliveries are as follows:

i. Formal lectures

Formal lectures are conducted to deliver knowledge and develop understandings among students on the fundamental and technical aspects of engineering. Lectures are normally conducted with the aid of multimedia tools as well as discussion. The total number of students per lecture session is limited to 40 people to ensure the effectiveness of teaching and learning activities.

ii. Tutorial

Tutorial sessions provide another means of solving chemical engineering problems in courses learned during lectures. Each tutorial session may accommodate a maximum of 15 students per slot.

iii. Case Study

A project refers to a short duration project which is assigned to students and normally carried out in groups. Depending on the course, the mini-project/ project can be based on a case study, simple design assignment/work, reading assignments, community service, or simulation work. This mini-project/ project will be assessed through systematic evaluation sets of rubrics.

iv. Seminar/Industrial Talk/Industrial Visit

This type of learning activity is embedded in the programme delivery to value the importance of exposure to industrial practices. Academics and industrial-related speakers with vast experience in the industry are invited to give talks and seminars on special topics related to problems and issues at industries which concern certain courses. Members of EH225 IAP panel are regularly invited to fulfil curriculum delivery such as industrial talk or evaluators for Design Project courses. Industrial visits are also organised to enhance students' know-how and exposure to the industry where the application of knowledge and theories learned during teaching and learning activities can be experienced first-hand.

v. Online learning

Students are exposed to problem-based learning, project-based assignments and independent/online learning of multimedia during their study. Blended learning activities are implemented in several ways in selected courses.

vi. Laboratory

Laboratory sessions consist of experimental work to demonstrate engineering theories that students have learned during lectures. Three different levels of experimental works have been assigned through problem-based learning activities during the laboratory sessions. A maximum of four students per group is designated for each experimental work.

vii. Final Year Project

The Final Year Project consists of two courses: Final Year Project I (CEV651) and Final Year Project II (CEV652) taken in semesters 7 and 8, respectively. The Final Year Project is individual, and each student is required to prepare and deliver both oral and written reports, with the guidance of a lecturer who acts as the project supervisor. The supervisor is responsible to monitor and guide his/her supervisees throughout the project at regular intervals. A series of lectures on research methodology will be given to help students carry out the course exercise. The structure of the research project report follows a standard thesis layout. Final Year Project I report usually consists of an introduction to the research topic, literature review, and detailed research methodology. In the second part of the final year project, tasks that have been carried in Final Year Project I continue to the Final Year Project II (CEV652), where the detailed results and findings are discussed thoroughly and concluded. For both CEV651 and CEV652, student's performance will be assessed through systematic evaluation based on standardized sets of rubrics.

viii. Integrated Design Project

The design project is the pinnacle of the Chemical Engineering Programme. The Integrated Design Project consists of two parts: the first part is Plant Design (CEV602) taken by semester 7 students and the second part is Design Project (CEV663) taken by semester 8 (final semester) students. The assessment of CEV602 is divided into two parts; 40% is contributed by assignments based on syllabus taught in class while the remaining 60% is contributed by design project (known as Design Project 1). The syllabus taught in class covers the chemical process and plant design through topics related to flow sheeting, product design, heuristic and guidelines in design, preliminary sizing of equipment, and pinch technology in environmental engineering. In the project-based assessment (Design Project 1), students are grouped into a group of 5 to 6 students. Each group is given a production plant design topic and supervised by a lecturer. In Design Project 1, each group is required to produce a report, which consists of chapters such as Process Background and Selection, Market Analysis, Site Selection, Environmental and Safety Considerations, Mass Balance, Energy Balance, and Process Simulations. Discussions and considerations of fundamental chapters (such as Process Background and Selection, Environmental and Safety Considerations, Mass Balance, and Energy Balance) must be presented for both the production plant and waste treatment plant. In Design Project (CEV663), students are required to carry out their projects on topics related to chemical/environmental engineering which is a continuation of Plant Design (CEV602) tasks. In this second part, detailed chemical and mechanical designs of major unit operations, process control, heat integration, process economic analysis, plant safety, environmental assessment, and waste treatment are carried out. It also emphasises the selection and design of the environmental control systems and wastes treatment plants. The assessment for CEV663 is 100% based on the project, and students are assessed using standardised sets of rubrics.

ix. Industrial Training

Industrial training is an important component of the engineering curriculum. Some theories learned during core and non-core courses will see their application in the real working environment in environmental industries. Before the actual training in industries, students are familiarised with standard procedures in job applications before stepping into the real working environment. Students are normally required to undergo a minimum of eight weeks of industrial training and instructed to follow the industrial training manual provided strictly before commencing the Industrial Training.

B. Delivery teaching method during MCO

The online learning delivery during the pandemic period is divided into two categories: synchronous and asynchronous (Daniel, 2020):

i. Synchronous learning

Synchronous online learning is a real-time learning activity where both parties interact online simultaneously such as chat, teleconferencing, video conferencing, live-streaming lecturers, and virtual classrooms. This type of learning allows direct interaction with fellow students and instructors during the lecture/tutorial. Likewise, synchronous assessment is conducted in real-time requiring both examiners and students to be online simultaneously. For example, real-time question and answer sessions and final year project presentations are conducted in this mode.

ii. Asynchronous learning

Asynchronous online learning allows learning at students' own pace without necessarily interacting with the instructors in real-time. In this mode, lecturers provide materials for reading, pre-recorded video/audio lectures as well as giving assignments, conducting tests, examinations, and other assessments. Students can access these materials at their convenience as well as completing and submitting tests, examinations, assignments, and other types of assessments within a flexible time frame. Methods of asynchronous online learning include self-guided lesson modules, pre-recorded video content, posted lecture notes, and exchanges across discussion boards or social media platforms.

III. Assessment Method

A. Assessment before MCO

Assessments are designed to achieve the course outcomes (COs) which are directly mapped to the designated PO statements. Each of the assessments is used to continuously monitor students' CO achievement and eventually grade them. The measurement of CO attainment is required to gauge the effectiveness of related teaching-learning delivery processes. There are two categories of assessment in this programme which might vary according to the level and specified CO as follows:

i. Examinable courses

Courses with examination would have a summative assessment which is the final examination at the end of the semester. Students are required to complete their coursework and a final examination with a minimum passing mark of 50% to obtain a pass C grade. In most cases, all fundamental and university requirement courses implement 60% final assessment and 40% continuous assessments (tests, quizzes, laboratory reports project reports, and assignments). The primary goal of this 60-40 configuration is to assess the knowledge capabilities of the students.

ii. Non-examinable courses

The non-examinable courses apply the continuous type of assessment i.e., the formative method. Students will be evaluated from tests, assignments, quizzes, laboratory reports, group projects, mini-projects, industrial visit reports, and final year thesis. The breakdown of assessment percentage depends on the individual course as specified in the systematic evaluation rubric of a particular course. Courses in this mode are normally designed to assess the skill capabilities and attitudes of the students. The assessments of non-examinable courses are evaluated through rubrics with specified criteria and standards for assessing different levels of performance for grading the student works. Students are being assessed through various approaches to ensure their performances are in line with the COs and POs requirements.

The assessment of the POs in the academic curriculum of EH225 is based on the year of studies as illustrated in Figure 1. In the first and second years of study, the assessment of PO was mainly contributed by PO1 and PO2. The more complex chemical and environmental engineering problems consisting PO3 are evaluated in the third and final year of study such as during the implementation of case studies in mini project exercises. Here, students are expected to integrate the element of the design complex engineering problems in their project assignments. The ability of students to assess the issues in engineering scenarios (PO6) as well as the capability on the independent and lifelong learning (PO11) is mainly evaluated during the third and final year of study.

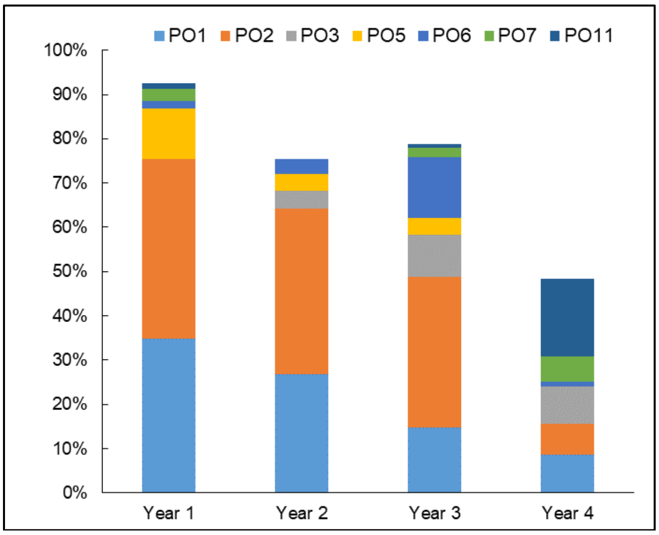

Fig. 1. Contribution of Cognitive Domain for Programme Outcomes Based on Year of Study

For the development of psychomotor capabilities in conducting the complex chemical and environmental investigation, the assessment of PO4 is introduced to the students in the form of open-ended laboratory activities. This attainment of PO4 is also contributed by industrial training and final year projects I and II during the final year of study, as shown in Figure 2.

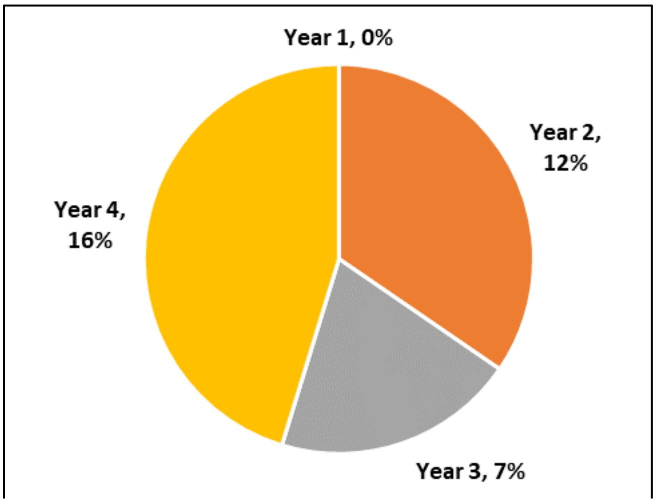

Fig. 2. Contribution of Psychomotor Domain for Programme Outcomes Based on Year of Study

Lastly, the attainment of the students on the affective domain especially in the communication (PO9) and teamwork skills (PO10) is mainly evaluated during the third year and final year of study as illustrated in Figure 3. Presentation is the main exercise to evaluate the mini-project/group project, integrated design project, and other skills involving teamwork, leadership, and creativity. These aspects of abilities are required to develop students' soft skills and confidence to communicate during industrial training and real workplace. The assessment of PO8 and PO12, which involve roles of engineers and ethical principles in project management, also contributes to the affective domain.

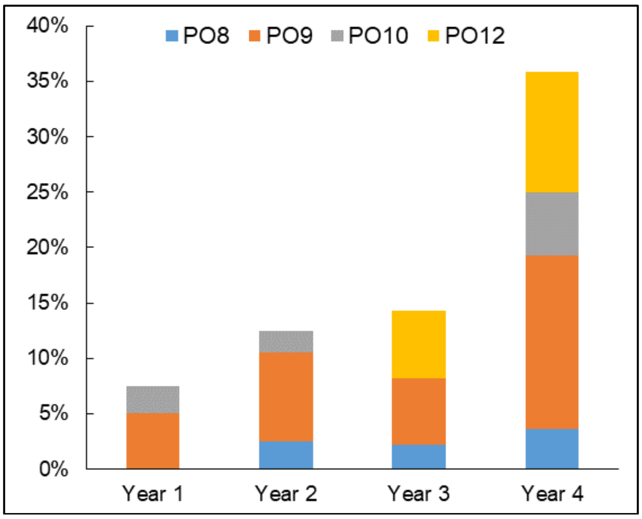

Fig. 3. Contribution of Affective Domain for Programme Outcomes Based on Year of Study

B. Assessment during MCO

During the online teaching and learning assessment, all assessments should be designed to be conducted online. The assessments is divided into two types, which are formative assessment, or continuous assignments, and summative assessment. Marks from both assessments are combined for the evaluation of the final mark. The assessment for both types must follow the approved weightage as stipulated in the Course Assessment Plan (CAP) that is linked to the PO of each course. This CAP was presented and endorsed at Jawatankuasa Akademik Negeri (JAN). The number of assessments of each course should not be more than four (4) assessments. The arrangement of these four assessments should be aligned to the cognitive domain based on the year of study as shown in Table 1.

Table 1: Cognitive domain (%) based on year of study

Year	***Cognitive domain***		
	C1-C2	***C3-C4***	***C5-C6***
1	20-35	45-55	15-20
2	25-40	40-60	15-30
3	15-30	40-60	25-40
4	5-10	45-55	35-45

The types of assessment can be written assignments, problem-based or project-based assignments, open-book tests, case studies, or others. For the presentation and laboratory conduct, students are required to do an online presentation, and/or submit a recorded version of their presentation in video format. For each course, the allocation of marks in all these assessments needs to be aligned with the percentage of course outcome (CO) and programme outcome (PO).

To ensure the quality of the summative evaluations (Gamage, Silva, et al., 2020), the vetting process is performed by the Resource Person (RP) and the appointed vetter. Additionally, students must fill out and sign an acknowledgment form for each submitted assessment to demonstrate the honesty issues.

IV. Discussion

The delivery method and implementation assessment are referring to the EAC standard and guideline principles on teaching-learning and assessment implementation during the Covid-19 pandemic (Engineering Accreditation Council, 2020a) (Engineering Accreditation Council, 2020b). The main comparison between the programme delivery and assessment method before and during MCO is discussed as below:

A. Laboratory Courses

During two semesters of the Covid-19 pandemic, the laboratory courses or courses with embedded laboratory were conducted as non-face-to-face (NF2F) that used problem-based assignment or simulation assignments. The virtual demonstration of laboratory procedures by the lecturers was implemented as the delivery method of experimental works. For the laboratory conduct evaluation, the online discussion and case analysis were implemented as alternative methods. Meanwhile, the attainment of the psychomotor domain (PO4) for the respective students for face-to-face (F2F) laboratory was higher than 50% compared to non-face-to-face methods during the pandemic and after three semesters of MCO.

B. Final Year Project I and II

For Final Year Project I and II (CEV651 and CEV652), the assessment schemes or marks distribution remain the same before and during the Covid-19 pandemic. Assessment on research conduct, assignments submission, reports submission, grading and presentations were entirely conducted online. During the Covid-19 pandemic, students were given the freedom to discuss with their respective supervisors to convert laboratory-based projects to either simulation/modelling or review and comparative studies. Projects which required laboratory experiments were allowed to be conducted in laboratories with strict compliance to SOP. For both March – July 2020 and October-February 2021 semesters, around 20-30% of final year projects were laboratory-based projects.

C. Integrated Design Project

For Plant Design/ Design Project I (CEV602) and Design Project II (CEV663), the assessment schemes or marks distribution remain the same before and during the Covid-19 pandemic. Assessments on students' conduct, assignments submission, reports submission, grading and presentations were entirely done online.

D. Industrial Training

For Industrial Training, the assessment marks distribution remain the same before and during the Covid-19 pandemic. During the Covid-19 pandemic, a batch of Part 7 students underwent internships at various companies from August to October 2020 for 8 weeks. For the assessment on students' conduct, the only difference was students' presentation to visiting lecturers and students' poster presentations during Industrial Training Showcase were conducted online.

In summary, the general comparison of the distribution of four assessments in the EH225 curriculum in the Course Assessment Plan during the pandemic is shown in Table 2.

Table 2 Comparison distribution of Assessment Method

No.	*Assessment before MCO*		*Suggestion assessment during MCO*		*Sample of Code Courses*
	Assessment method	%	Assessment method	%	
CASE 1					
1	Quiz/Assignment	20	Written Assignment	20	CEV403
2	Test 1	10	Online Test	20	
3	Test 2	10			
4	Final exam	60	Online Test	30	
			Problem Based Assignment	30	
CASE 2					
1	Quiz/Assignment	10	Written Assignment	30	CEV407 CEV420 CEV422
2	Test 1	10			
3	Test 2	10			
4	Mini project	10	Case Study	10	
5	Final exam	60	Online Test	30	
			Problem Based Assignment	30	
CASE 3					
1	Quiz/Assignment	20	Written Assignment	50	CEV623
2	Test	30			
3	Mini Project	10	Case study	10	
4	Final Exam	40	Problem Based Assignment	40	
CASE 4					
1	Quiz/Assignment	20	Written Assignment	20	CEV631
2	Case study	20	Case study	20	
3	Test	20	Online Test	20	
4	Community Programme	40	Project	40	
CASE 5					
1	Test	10	Online Test	10	CEV452
2	Lab Conduct	60	Lab Conduct	20	
3	Lab Report	30	Problem Based Report	30	
4			Case Analysis	40	
CASE 6					
1	Quiz/Assignment	5	Assignment	13	CEV544
2	Test	15	Virtual Presentation	10	
3	Lab Report/Conduct	20	Case Study	10	
4	Final Exam	60	Online Test	67	
CASE 7					
1	Assignment	20	Written Assignment	20	CEV641
2	Test	20	Case Study	20	
3	Project	40	Project-Based Report	40	
4	Presentation	20	Video Presentation	20	
CASE 8					
1	Assignment	10	Problem Based Assignment	10	CEV444
2	Test	20	Online Test	20	
3	Lab Conduct	40	Lab Conduct	40	
4	Lab Report	30	Report	30	
CASE 9					
1	Assignment	40	Written Assignment	40	CEV602
2	Project	60	Project	60	
CASE 10					
1	Report	60	Report	60	CEV651
2	Presentation	20	Virtual Presentation	20	
3	Originality Assessment	10	Originality Assessment	10	
4	Research Competency	10	Research Competency	10	
CASE 11					
1	Report	40	Report	50	CEV652
2	Presentation	10	Virtual Presentation	10	
3	Originality Assessment	10	Originality Assessment	10	
4	Research Competency/ Lab Conduct	30	Research Competency	30	
5	Manuscript	10	-		
CASE 12					
1	Design Project Report	60	Design Project Report	60	CEV663
2	Peer Evaluation	10	Peer Evaluation	10	
3	Presentation	20	Online Presentation	20	
4	Student Attitude	10	Student Attitude	10	

V. CONTINUOUS QUALITY IMPROVEMENT

Based on the comparison of delivery and assessment before and during Covid-19, the improvement on the quality assurance is required to improve the effectiveness of learning. Gamage et al. (2020) reported that benchmarking on academic strategy and educational design is important to identify the excellence and best practice especially for online methods of laboratory-based learning (Gamage, Wijesuriya, et al., 2020). Zhai et al. (2012) compared the effectiveness of three different types of experiments focus on the electrical engineering laboratories (Zhai et al., 2012). It shows that the virtual experiment gives a good learning effect to the students. However, the combination of various methods is widely adapted depends on the contents and outcomes of the courses. Other studies from Maqableh et al (2021) show that COVID-19 Pandemic affects assessment due to learning experience and satisfaction as they encountered various types of problems such as technological, psychological, financial, time management, and balance between life and education (Maqableh & Alia, 2021). Hence, it cannot be denied that ODL has benefited most of the students due to the availability and accessibility of the lesson especially on complex topics (Lapitan et al., 2021).

VI. Conclusion

In conclusion, the EH225 curriculum courses have been developed to be consistent with the wide-ranging intellectual and practical skills as well as attainment of the Programme Outcomes statements even during the pandemic period. As Covid-19 cases rise and fall during the semester ahead, the implementation of Open Distance Learning will likely continue to balance educational needs with protecting the health of students and university communities. Institutions, lecturers, and students need to prepare and play a new role to support teaching and learning to adapt to the huge challenge in the education systems during and after the Covid-19 pandemic. In addition, in the long-term perspectives, the adoption of online learning offers improvements and experiences to accelerate thinking on how to improve the quality of education in the new norm and for the next generations.

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