

INTERNATIONAL JOURNAL OF
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(IJMOE)www.ijmoe.com**IMPLEMENTATION OF OUTCOME-BASED EDUCATION
(OBE) IN CHEMICAL ENGINEERING PROGRAMME: REVIEW
ON STUDENTS' PERFORMANCE IN DESIGN PROJECT
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Abstract:

Outcome-based education (OBE) is an effective goal-driven method to measure the outcomes of a curriculum. Its implementation in Bachelor of Chemical Engineering Programme at UiTM Pulau Pinang ensures the integrity of the assessments on various components of the course and improves the course delivery methods and student's expected attributes. Implementation of OBE throughout 2020 to 2023 coincided with tumultuous years of 2020 and 2021 where COVID19 restrictions impacted many learning activities. Thus, using Design Project (DP) as a case study, a review on students' performance throughout this period was conducted based on the course outcome (CO) and programme outcome (PO) which were mapped to various components of the course. Generally, students' performance in DP course were not significantly different throughout 2020 to 2023 period, while their CO/PO attainments exceeded minimum target of 50% across the entire CO/PO attributes, with only one instance in 2020 where a CO/PO score did not meet the minimum threshold. Additionally, students' own assessment through questionnaires strongly suggested their perceived attainments in all COs. In conclusion, steady

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performance of students during implementation of the DP course throughout 2020 to 2024 demonstrated the robustness of OBE assessment method.

Keywords:

Outcome-based Education, Design Project, Course Outcome, Programme Outcome

Introduction

Outcome-based education (OBE) has been widely adopted by higher learning institutions as a robust method to measure student's achievement (Kumar, 2021). Contrary to input-based education, OBE outlines specific attributes known as programme outcome (PO) that are distributed across various subjects in the curriculum structure of an academic programme. Students' attainment to these attributes ensures their adequate competency to the programme, relevant skill set for employment and nurturing positive attitudes to society (Mahbubul et al., 2022). Indeed, the term 'constructive alignment' perfectly describes OBE implementation as continuous review to its PO(s) is regularly done in every 2.5-year cycle, while major review takes place every four-to-five-year cycle. As OBE is the primary tool used by the accreditation body, its implementation ensures the relevance of an academic programme to current job market needs i.e. reducing the gap between skills acquired by students through education and the skills needed in the workplace (Sumathi et al., 2024). This is especially true in engineering as it is a constantly evolving field with new technologies and techniques rapidly emerging. Thus, engineering education must be equipped with tool to ensure its relevance to contemporary needs in related profession. Nonetheless, critics argue that over-rigidity of OBE undesirably restricts student's self-discovery, self-learning and self-inquiry. Such argument may be true for liberal courses such as art and humanity, while engineering discipline requires a pre-determined set of skills which can only be practically acquired through a rigorous curriculum which is defined by specified course outcomes.

Meanwhile, Design Project (DP) course (course code: CEV663) is a capstone, project-based course which is undertaken by final year student of Degree of Chemical Engineering (Environment) programme (programme code: EH225) at Universiti Teknologi MARA (UiTM) Pulau Pinang. The course is a culmination of engineering knowledges, concepts and theories undertaken by students in the preceding semesters of their four-year programme. DP is amongst advanced courses which carries the highest credit hour (four credit hour) with most PO(s) allocation namely; PO3 (design ability), PO6 (safety, health and legal assessment), PO9 (communication), PO10 (teamwork), PO11 (independent learning) and PO12 (project management). The implementation of DP course throughout 2020 to 2023 coincided with COVID19 breakout in 2020. The most challenging period was during 'lockdown' or 'stay at home' order which took effect in March 2020 which hampered normal learning activities. Project-based course such as DP was perceived as among the most impacted where normal activities such as discussion, educational site visit, presentation and other physical communications for the completion of the tasks were hindered. Amid these challenges, Malaysian Qualifications Agency (MQA) issued advisory guidelines to higher education providers (HEPs) to modify face to face learning into online approaches while maintaining the equivalent learning outcomes and the integrity of alternative assessment methods (Paul Leong, 2022a).

This study shed light on the implementation of OBE in Bachelor of Chemical Engineering (Environment) studies (programme code: EH225) offered at the Universiti Teknologi MARA Pulau Pinang. As a case study, the robustness of OBE assessment tools was evaluated by reviewing the students' performance throughout the year 2020 to 2023 in Design Project (DP) course based on their PO and course outcome (CO) attainments. During this period, special attention was given to the performance during the period with COVID19 restrictions (2020-2021) in comparison to normal times (2022-2023).

Outcome-based Educational (OBE) Framework of EH225 Programme

Programme Educational Objectives (PEO) is the long-shot indicator for the effectiveness of OBE implementation where career and professional life achievements of the graduates after three to five years of graduation are evaluated. Historically, the first PEO statements for EH225 programme i.e. three PEOs were introduced when the programme was inceptioned in 2012 (then EH224). Ever since, PEO statements were revised every 6-year cycle; the first revision took in 2018 (two PEOs) and the latest ones are expected to take effect at the end of 2024. The evolution of PEOs since 2012 to present is shown in Table 1.

Table 1: Evolution of Programme Educational Objective (PEO) for EH225 Programme

	Year of implementation: 2012	Year of implementation: 2018
PEO1	Demonstrate professional competencies in chemical and environmental engineering fields/organization	Demonstrate the ability as competent chemical engineers with the potential to become leaders in chemical and environmental or related industries.
PEO2	Engage in effective communication, team work and leadership across organization or surrounding community.	Bumiputra graduates who are ethically dedicated towards sustainable development in chemical and environmental or related industries for the societal and nation benefits.
PEO3	Engage in lifelong learning through professional career development and/or advanced studies.	-

PEO statements were rigorously designed to transpire the mission and vision of both Faculty of Chemical Engineering (as the provider for EH225 programme) and UiTM (as the institute of higher learning (IHL)). In addition, views from various stakeholders including employers, industrial advisers and multilayered university committees were considered. Later on, alignment of PEOs to Programme Outcome (PO) stipulated by EAC regulator was diligently made at course level. These processes were carried out in stages and their interconnection throughout objective (the PEO), programme (the PO) and course (the CO) levels are shown in the OBE implementation framework of Figure 1.

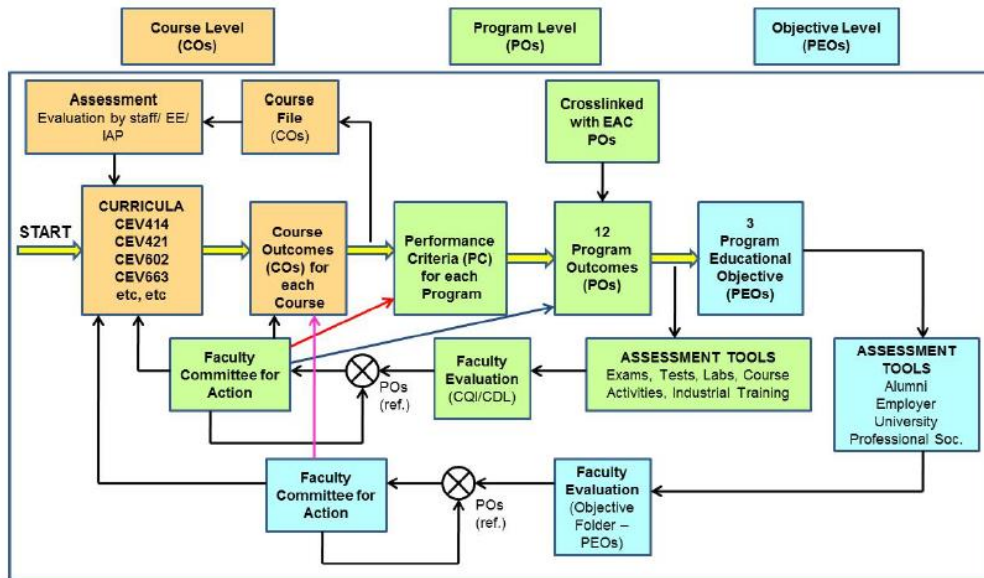


Figure 1: Framework of Outcome-based Education (OBE) Implementation for EH225 Programme

Within this intricate framework, involvement of stakeholders e.g. alumni and industry and continuous quality improvements (CQI) which safeguard the integrity of the OBE system at any given cycle is clearly demonstrated in Figure 2.

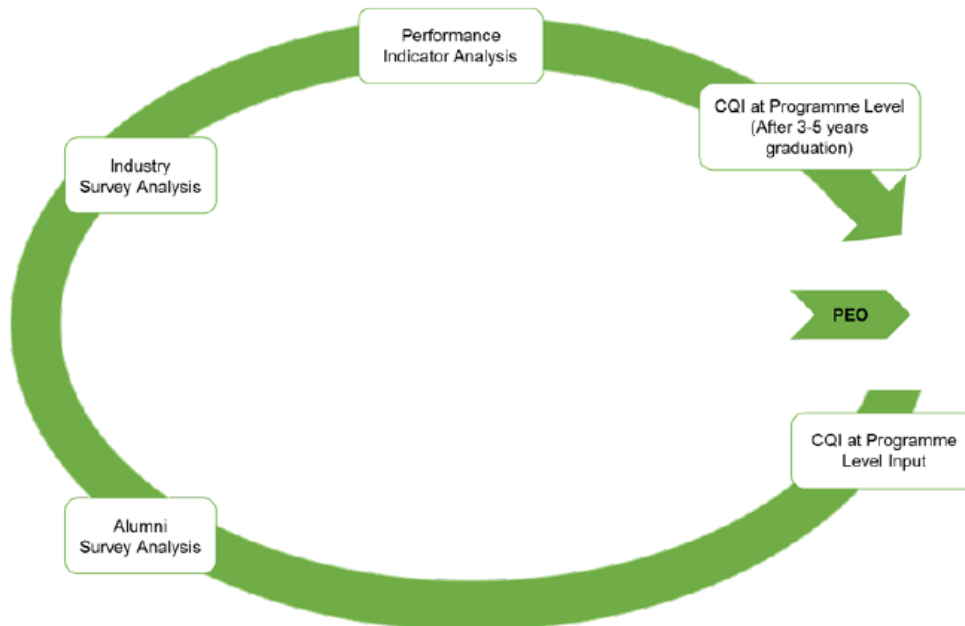


Figure 2: Programme Educational Objective (PEO) Cycle

Programme Outcomes (PO) and Course Outcomes (CO) Pertaining to DP Course

Assessment of student's achievement in course was carried out directly based on course outcome (CO) which reflected acquisition of tangible knowledge and skills by the student

during the course undertaking. These COs were also mapped to suitable POs (Table 2) which served as constructive alignment tool e.g. towards ultimate PEO attainment for the DP course.

Table 2: Course Outcome (CO) and Programme Outcome (PO) Mapping for DP Course

CO	Description	PO
CO1	Propose a complex plant design that is technically feasible and cost effective based on the project requirements.	PO3
CO2	Design a process plant that complies to environmental and safety standards based on the project requirements.	PO6
CO3	Explain a final design project through oral presentation with proper organization and articulation of data.	PO9
CO4	Perform responsibility as an effective team member in performing task based on professional, integrity and ethical practice.	PO10
CO5	Integrate the knowledge and understanding of engineering principles and managing principles to manage a project in multidisciplinary environments.	PO12
CO6	Assess engineering issues in related fields towards lifelong learning.	PO11

OBE implementation in EH225 programme is a dynamic, engaging and continuous process. For example, students' awareness about OBE aspirations was constantly reminded by explicit CO-PO statements in the course outline, assignment sheets and examination of every course students undertake. Furthermore, refresher talk about OBE is held at every semester. Another rigorous aspect of OBE implementation is continuous quality improvement (CQI) exercise which is carried out at the end of every semester involving DP course coordinator and lecturers to evaluate OBE achievement. The implementation of OBE at course level is summarised in Figure 3.

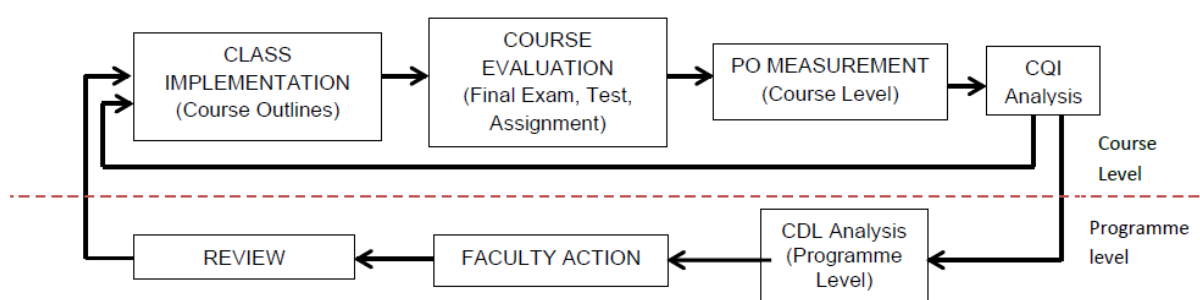


Figure 3: Outcome-based Education (OBE) Implementation Cycle

As the accreditation body i.e. Engineering Accreditation Council (EAC) for EH225 programme is a signatory to Washinton Accord, mapping of COs and POs to the convention was made in 2020 were made to all complex problem-solving profiles i.e. WP1 to WP7, some elements of graduate attributes and knowledge i.e. WA3/WK5 and WA7/WK7 and all complex engineering activities profiles (EA1 to EA5). This latest development took effect in 2021 and put to use in the rubric assessment for evaluating the assignments pertaining to detailed chemical and mechanical designs of equipment. For example, aspects of design heuristics, calculations and feasibility which formed the crux of the assigned tasks were aligned to a wide range of complex engineering problem classification i.e. WP1 to WP7.

Meanwhile, there was no change in the assessment structure in implementation of the course during COVID19 restrictions in 2020 i.e. same distribution of marks for reports, presentation, peer evaluation and attitude. Throughout year 2020 to 2021, most of these activities were carried using ODL.

Data Collection for OBE Evaluation for DP course

Evaluation of OBE implementation for DP course was made based on Course Outcome (CO) and Programme Outcome (PO) attainments. The performance of four batches of students throughout 2020 to 2023, each consisted of 119(2020), 54 (2021), 49(2022) and 56(2023) students, respectively who undertook the course in March-August semester were collected for evaluation. The CO/PO attainment was contributed by written reports, presentation, attitude and peer evaluation based on the fulfillment of criteria articulated by their respective rubric sheet. No changes in rubric criteria were made during 2020 to 2023 period. Breakdown of marks and weightage of each assessment component is shown in Table 3.

Table 3: Breakdown of Marks and Weightage of Assessment Component in Design Project (DP) Course

Assessment	Report	Peer evaluation	Presentation	Attitude
Obtained marks	p	q	r	s
Full marks	w	x	y	z
Weightage	60%	10%	20%	10%

Score of a particular CO by an individual student was calculated based on the score of its corresponding PO which was the sum of fraction of obtained marks of its full marks of each course component multiplied by its weightage percentage, as follows:

$$\text{PO/CO score} = \frac{p}{w} \times 60\% + \frac{q}{x} \times 10\% + \frac{r}{y} \times 20\% + \frac{s}{z} \times 10\% \quad (1)$$

CO and PO attainments were categorized into three categories; fail, pass and good according to the values of their respective CO/PO average i.e. level 1 (0-49%), level 2 (50-64%) and level 3 (65-100%). In other words, successful CO and PO attainments of DP course were conferred to individual PO score of at least 50%. Average value of these individual scores was later calculated to reflect the average CO/PO attainment of a particular CO/PO. In addition, the frequency of individual CO/PO score of at least 50% was calculated as CO/PO density. For example, 40 of 50 students who obtained at least 50% of CO1/PO3 corresponds to 80% of CO1/PO3 density at which EH225 set its own minimum target of 75%.

Another assessment was carried out using entrance-exit survey which made up of questionnaires related to course outcomes and students' own assessments to their achievement to these outcomes. This was a form of indirect assessment as it was not counted directly into CO/PO attainment but rather a general appraisal of the course effectiveness from the student's perspective. Questionnaires were disseminated at the beginning and the end the course where students rated their ability to each course outcome (feasibility, environment/safety, presentation, teamwork and integration of knowledge) according to 1 to 5 scale before and after undertaking the course. The attainment to each course outcome (CO) was calculated from the average rating given by all students. For example, average rating of CO1 (Design feasibility)

attainment in 2020 was 4.4 i.e. the average rating of 42 individual students who rated their respective perception towards CO1 attainment in the scale of 1 to 5.

Results and Discussion

Average programme outcome (PO) and course outcome (CO) throughout 2020 to 2023 generally achieved more than 50% minimum target as shown in Figure 4. In addition, there was no drastic change in PO and CO attainments throughout this period despite COVID19 restrictions in 2020 and 2021. This achievement was later translated into 100% CO/PO density which was consistently recorded throughout 2020 to 2023 (data not shown), with an exception in 2020 where an individual CO/PO score was less than 50%. Interestingly, elements of teamworking stipulated by CO4/PO10 earned the highest score of more than 90% including the year 2020 and 2021 during which much of the COVID19 physical restrictions were in place. On other hand, elements pertaining to presentation (CO3/PO9) showed the least score of less than 70% in 2020, 2021 and 2022 among other POs and COs, except in 2023 where the score was slightly above 70%.

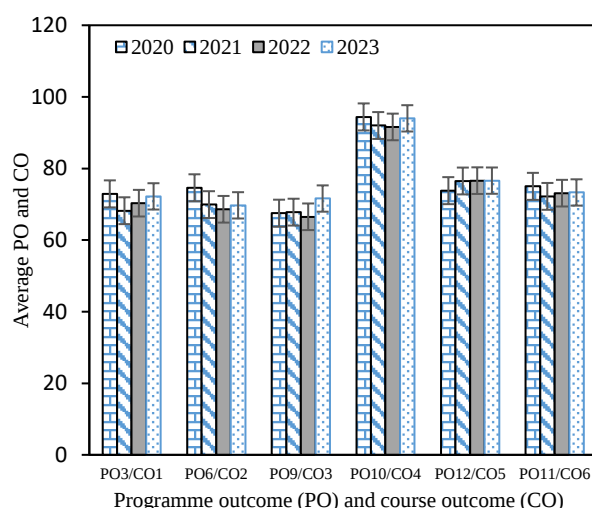


Figure 4: Average Programme Outcome (PO) and Course Outcome (CO) throughout 2020 to 2023 Period

A closer look into the variation of CO/PO performance throughout 2020 to 2023 using 2023 as baseline reference is shown in Figure 5. A slight decline was observed in most CO/PO during 2021 and 2022 performance relative to 2023. Interestingly, all CO/PO performances in 2020 except CO3/PO9 and CO5/PO12 during which most COVID19 restrictions were in place were higher relative to 2023.

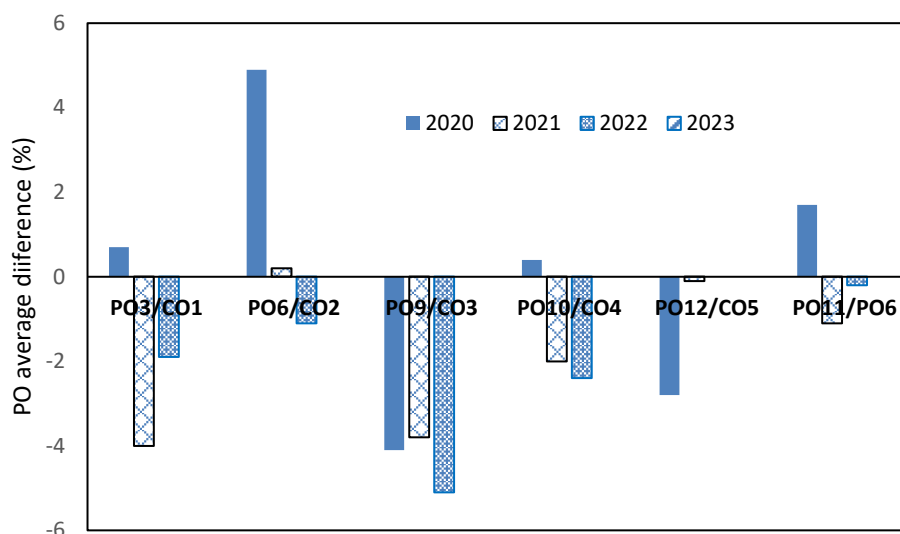


Figure 5: Difference of Programme Outcome (PO) Average Relative to 2023 Performance

Student demonstrated very high level of approval rating (>4) towards their own attainments in all course outcomes (CO) as shown in indirect assessment in Figure 6. This trend was consistent throughout 2020 to 2023. Despite possible negative impacts of COVID19 restrictions to learning activities especially in 2020 and 2021, there was no significant change in student's overall perception towards their CO. Researchers generally agreed that psychomotor domain e.g. PO4 was the most significantly impacted during COVID19 restrictions (Paul Leong, 2022b). In the context of DP course, all of its POs fell within cognitive domain, thus explained why the student's performance was only minimally affected by physical restrictions. In the wake of COVID19 restrictions, EH225 programme had implemented the directive from academic affairs department of the university to convert face-to-face summative assessments into problem-based assignments during implementation of open and distance learning (ODL). These changes were carried out with strict adherence to OBE specifications of the original assessments. Although no change in assessment structure was made on the DP course itself, the changes in other courses had contributed to students' ability to adapt to new learning approaches which mitigated any negative effects of physical restriction during the DP course undertaking.

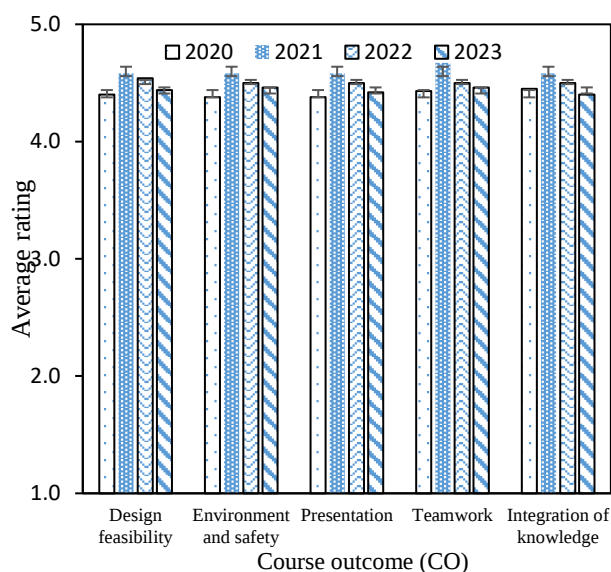


Figure 6: Average Student's Self-rating for Course Outcomes (COs) Throughout 2020 to 2023

Comparative observation on student's own perception towards attainment of various course outcomes is shown in Figure 7. Their perceived attainment towards these outcomes declined in 2020 relative to 2023 (albeit insignificant for less than 1%), except the course outcome pertaining to integration of knowledge. Despite the perceived negative impacts of COVID19 restrictions, some studies suggested that better time management ability was demonstrated by students during isolation. In the context of DP course, good internet connectivity at home and campus may have contributed to good satisfaction of students towards CO attainment and helped to mitigate the negative impacts of COVID19 restrictions. This assumption was based on the opposite effect of poor internet connectivity which contributed to poor perception of learning effectiveness among students in underdeveloped countries (Karimi et al., 2021). Moreover, students who undertook DP course were final students who had accumulated some degree of maturity and discipline during the preceding years, thus more adaptive to COVID19 restrictions. The negative impacts of COVID19 restrictions were also minimized by quick adaptability both instructors and students to new style of online learning despite difficulty at the early stage of transition. Different forms of online learning activities such as pre-recorded lectures, interactive Q&A sessions and quizzes for self-assessment created an equally effective teaching and learning activities (Grodzki et al., 2021).

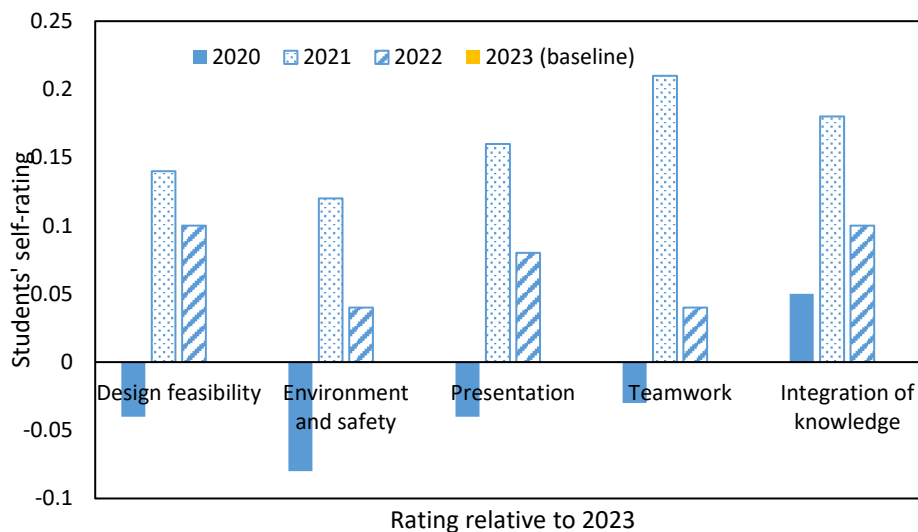


Figure 7: Variation of Student's Self-rating towards Course Outcome (CO) Attainments Throughout 2020 to 2023

Our finding on minimal impact of COVID19 restrictions on student performance was supported by the numerous studies on the impacts of COVID19 in engineering education. These studies suggested that the use of innovative tools in blended learning approaches and more frequent problem-solving exercises during open and distance learning (ODL) implementations had enabled better motivation and engagement among students which resulted better satisfaction than pre-pandemic time (Nahar & Baillie, 2022). Apparently, numerous studies demonstrated the robustness of OBE assessment tool in maintaining the integrity and validity of the students' performance amid modification to assessment methods from normal face to face learning to ODL (Zaiton et al., 2021). For instance, satisfactory students' performance in laboratory course of electric engineering diploma programme at UiTM Johor was achieved during COVID19 restrictions. Using similar PO attainment to this study as a measurement to student performance, all POs exceeded minimum KPI of 65% while PO related to effectiveness as member of teamwork scored the highest attainment which implied the effectiveness of the remote learning tools e.g. Microsoft Team and Whatsapp as teaching delivery and communication platforms, respectively which were used extensively. Interestingly, PO related to written and verbal communication scored the lowest attainment which was coincidentally similar to the trend shown by our study (Abd Latiff et al., 2022). Other studies also found that the shifting of learning approach from teacher-centred to student-centred learning using problem-based learning (PBL) approaches during COVID19 had emboldened student's aptitude for innovative learning activities as well as encouraging more active and engaging learning behaviours (O'Connor et al., 2024). Since DP course possesses a lot of PBL characteristics, students' ability to cope with COVID19 restrictions was not unexpected as these problem-solving skills were simultaneously acquired from other subjects which adopted similar PBL approaches. Our finding in non-significant drop in students' performance in DP course also agreed with a study conducted on a civil engineering students of San Diego State University (SDSU). Based on student outcome (SO) and students' own perception assessments, the latter study discovered an insignificant decline in course outcome performance (Supernak et al., 2021) during COVID19 restrictions due to quick adaptability of both students and instructors to remote learning mode.

Minimal impacts of COVID19 restrictions on project-based courses such as DP can be intuitively justified by the stark contrast of COVID19 restrictions impact on other non-project or theoretical-based courses which traditionally require close tutoring, face-to-face learning activities and examination-based summative assessment. Due to reliance on traditional teaching and learning methods, less-adaptability to remote and online learning approaches was widely reported as the cause of poor performance in the courses of this nature (Huei Lee et al., 2022). Furthermore, assessment component which involved examination was downgraded by the negative perception of instructors towards unethical behaviour such as cheating (Asgari et al., 2021). The drawbacks of remote learning can be mitigated by extensive use of effective online tools e.g. Google Meet, Google Classroom, Microsoft Teams, U-Future (UiTM e-learning) coupled with modification of assessment approaches to suit with online and distance learning environment. As a result of converting test and examination (of normal face to face learning) to continuous problem-based assessments of ODL, while maintaining the equivalent POs between normal face to face and ODL modes, better students' performance in terms of PO attainment was demonstrated in Basic Structural Analysis course of Civil Engineering Diploma Programme at UiTM Johor during COVID19 restrictions (ODL mode) as compared to the performance during normal face to face learning (Wan Chik et al., 2021). Nonetheless, despite the apparently better cognitive achievement of students during ODL as compared to normal face to face, the integrity of students' true achievement was questionable without an effective invigilation during online test (Syed Yahya et al., 2023).

Conclusion

Robustness of OBE assessment tools was demonstrated by consistent performance of CO and PO attainments throughout 2020 to 2023. All areas of CO and PO achieved much higher score than minimum target of 50% average CO/PO throughout this period, despite COVID19 restrictions in 2020 and 2021. Furthermore, students also agreed their own attainments to course outcomes based on their average ratings to questionnaires. Students' own experience in utilizing innovative tools and exposure to blended learning approaches of ODL during pandemic had possibly enabled them the ability to adapt and mitigating the negative effects of physical and social restrictions. Our finding which suggested insignificant effect of COVID19 restrictions on students' performance in DP course was not unique as similar finding was observed in engineering programmes of other universities.

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