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Reliability of Program Outcome Attainment Evaluation Based on Cumulative Model and Culminating Model Analysis

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ABSTRACT

Program outcomes (POs) are essential components in outcome-based education (OBE), reflecting a graduate's attribute and ability to demonstrate competencies at appropriate levels. Typically, POs are derived from the graduate attributes (GA) specifi ed by accrediting bodies such as the Engineering Accreditation Council (EAC). The attainment of POs is assessed through various methods, including direct and indirect assessment tools. This study evaluates the reliability and effectiveness of POs attainment analysis and measurement using cumulative model and culminating model approaches. The analysis was conducted on a cohort of 226 students who graduated in September 2017, consisting of two entry channels: 115 diploma students and 111 matriculation students. Comparative analysis results indicate that both models reliably measure POs attainment, however the culminating model shows better performance of POs attainment compared to the cumulative model. The average percentage difference between the two models for diploma students is 4.64% and no difference for PO9 and PO10. For the matriculation intake group the average percentage difference between the two models is 3.82% and no difference for PO6 and PO11. In conclusion, both models facilitate systematic POs attainment analysis for all students and provide insights into the strengths and limitations of each model, contributing to the ongoing improvement of OBE practices and ensuring that graduates meet the required competencies and standards.

Keywords: Program outcome; outcome-based education; graduate attribute; accreditation & continuous quality improvement

INTRODUCTION

Outcome-Based Education (OBE) has been implemented in Universiti Teknologi MARA (UiTM) specifically at Civil Engineering Studies, College of Engineering to promote student-centered learning by aligning the educational objectives with the desired program graduate outcomes. Additionally, the OBE system aids in the Continuous Quality Improvement (CQI) process, enhancing teaching and learning through systematic analysis and stakeholders' feedback (Kumar & Singh, 2019; Guggari et al. 2023). The implementation of OBE has effectively improved the quality of engineering educational programs and assist in reducing variation in the quality of the graduates (Ali 2024; Asim et al. 2023; Qadir et al. 2020)

Based on Criterion 2 derived from the Graduate Attributes (GA) of Engineering Accreditation Council Standard 2020 (EAC Standard, 2020), the program outcomes (POs) outline the knowledge, skills, and behaviors that engineering students are expected to acquire by the time they graduate (Abbas et al. 2023). These outcomes specify what students should be able to know and do as a result of completing the program. For the Civil Engineering students in UiTM Cawangan Pulau Pinang, the program outcomes of the students are measured from the attainment of students from various courses and cumulatively calculated towards the end of their studies. Twelve POs are considered based on the EAC Standard 2020 which involves all three domains, i.e. cognitive, psychomotor and affective as tabulated in Table 1.

The Program Outcomes stipulated in the EAC 2020 Standard is considered as the critical aspect of OBE to represent the overall abilities that the graduates should acquire. These can be considered as the attributes that should be embedded in the mind and action of future engineers. Proper alignments of POs are necessary to ensure the graduates acquire essential competencies for their engineering career (Rajak et al. 2019). POs represent the knowledge, technical and soft skills and the abilities that make an engineering graduate competent and able to adapt with the working environment (Othman et al. 2022).

TABLE 1. Program Outcomes for Bachelor of Engineering (Civil) Honors (Infrastructure)

Program Outcomes		Domain
PO 1	Engineering Knowledge	Cognitive
PO 2	Problem Analysis	Cognitive
PO 3	Design/Development of Solutions	Cognitive
PO 4	Investigation	Cognitive
PO 5	Modern Tool Usage	Psychomotor
PO 6	The Engineer & Society	Affective
PO 7	Environmental & Sustainability	Affective
PO 8	Ethics	Affective
PO 9	Individual & Teamwork	Affective
PO 10	Communication	Affective
PO 11	Project Management & Finance	Affective
PO 12	Lifelong Learning	Affective

A suitable and effective PO assessment at the end of the students' study years is most essential, especially for the CQI process which is the heart of the Outcome Based Education (OBE) in the engineering program. Appropriate PO attainment of the graduates enables the center of study to meet the evolving needs of the students themselves and the industry as the main stakeholder of the program. An effective CQI will allow the Civil Engineering Study to enhance their teaching and learning to offer quality education for future graduates. These program outcomes are closely related to the long-term program educational objective (PEO) that is assessed within 3-5 years after graduation. Therefore, continuous improvement the engineering education an essential cyclical process of action, assessment, reflection and adaptation (Jakhale & Attar, 2015; Zamri et al. 2010). In other words, the PO assessment could assist in monitoring the engineering students' performance and teaching efficiency through the attainment levels (Santhi Rani et al. 2018).

This paper will focus on the comparison of two types of POs assessment models which are the culminating and the cumulative model. This analysis is carried out to compare the final PO attainment of students upon the time of graduation. The findings on this paper will enable proper evaluation of both methods' reliability and accuracy.

BACKGROUND

The Civil Engineering Studies in UiTM Pulau Pinang Branch has implemented OBE since 2007 starting with the awareness programs held for the lecturers and for the students. The journey continues towards nurturing the OBE culture in the teaching and learning process throughout the center of study. The application of OBE also requires a tedious data management process which also continues to evolve over time. The Civil Engineering Studies program initially used Microsoft Excel spreadsheets for managing Program Outcomes (POs), then transitioned to the OBE-SCL system, followed by MyCOPO, and currently utilizes the latest i-RAS system starting from year 2018.

All data acquired from all courses are then compiled, uploaded and analyzed through Program Outcomes Monitoring System for Civil Engineering Students (POSCES). POSCES is a web-based system that can be accessed through the Civil Engineering Studies website to help the data management process and data analysis of the Program Outcomes throughout the center of study. For this study, all data is collected from the in-house developed POSCES to manage the OBE system.

The flow of the OBE system implemented in the Civil Engineering Studies UiTMCPP is illustrated in Figure 1. Through teaching and learning, the assessment marks will be tailored directly to the COs and POs of the courses. All data of the CO and PO attainment are recorded in the i-RAS system by the course coordinators. The completed i-RAS templates are then submitted to the OBE webpage for the analysis by the OBE committee.

Data from i-RAS system are then analyzed at program level in the POSCES system. The PO attainments can be accessed in view of individual students, by courses, by semester exam, as well as by cohort (intake). A thorough analysis process could assist in the continual quality improvement (CQI) of the program towards a better implementation of teaching and learning. The PO attainment and the CQI actions taken by the center of study must be submitted to Unit Hal Ehwal Kurikulum (UHEK) of the campus and presented to the Jawatankuasa Akademik Negeri (JAN). This cyclic process is to ensure that the improvement of the program continues. The flow of the OBE process is presented in Figure 1.

At present, the Civil Engineering Studies measures all POs attainment of students starting from Year 1 to Year 4.

The measurement considers the students attainment from all engineering courses taken throughout their study years considering the cumulative model. At the end of study, all POs attainments will be accumulated, and the average overall achievement can be evaluated.

In the Civil Engineering Studies, the students' performance is measured according to the designated Key Performance Indicators (KPI) for the program prior to their graduation at course and program level. The KPI set is shown in Table 2 and minimum target for the overall PO average is at least 50% considering the passing marks for the courses presented in Table 3.

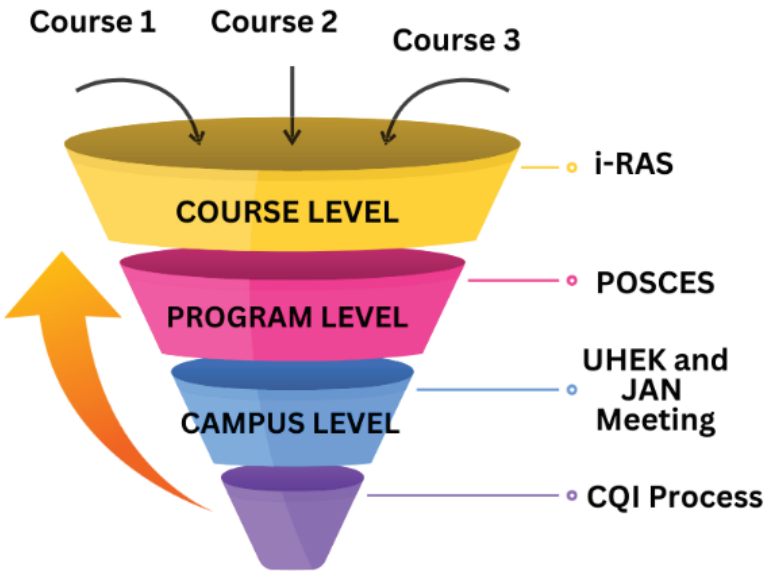

FIGURE 1. OBE System in Civil Engineering Studies.

TABLE 2. Key Performance Indicator for Program Outcomes (OBE Manual 3rd Edition, 2022)

PO Score (%)	Category	Indicator
100 – 80	Excellent	Pass
79 – 60	Good	
59 – 50	Moderate	
49 – 0	Fail	Fail

TABLE 3. KPI target (OBE Manual 3rd Edition, 2022)

PO Score (%)	Status
50 – 100	Compliance
0 - 49	Non - compliance

At present, the Civil Engineering Studies measures all the PO attainment of students starting from Year 1 to Year 4. The measurement considers the students attainment from all courses taken throughout their study years. At the end of study, all PO attainments will be accumulated, and the overall achievement can be viewed. However, it should be noted that in general, there are three types of Program Outcomes Assessment Models that are applied by various institutions of higher learning. These models dictate how the final PO attainment is summarized and accumulated for each student.

The Program Outcomes Assessment Models are as follows:

1. Culminating model: considers only a few selected courses in the final year of study. The selected course are usually capstone courses such as the Integrated Design Project, the Final Year Project and other final year subjects as well.
2. Dominating model: considers only selected core courses, usually the ones that dominates the attainment

3. Cumulative model: considers all engineering courses in the program) that is used by various institutions.
4. Comprehensive culminating model as proposed by Liew et al. (2021).

All assessment models are accepted for accreditation by the Board of Engineers Malaysia depending on the decision by the institution themselves (Sundararajan & Gopalan, 2020). Selection of the program outcomes assessment models will be able to drive the CQI process effectively with sustainable effort.

Furthermore, apart from PO measurements, it should also be noted that each course is also mapped to specific course outcomes that is tailored to the contents and the nature of the course. The course outcomes for the culminating courses discussed in the paper are presented in Table 4.

TABLE 4. Course Outcomes for the Culminating Courses

Course	Course Outcomes
CEC591	CO1: Formulate problem statement from issues related to the field of infrastructure engineering. CO2: Organizing necessary processes for completing a given project. CO3: Formulate objectives and research methods consistent with the problem statement. CO4: Arrange data and information gathered in a structured manner. CO5: Write and justify the proposed study.
CEC592	CO1: Carry out activities in order to achieve research objectives. CO2: Adopt the planned research method according to the schedule. CO3: Conduct analysis using suitable analytical and statistical tools. CO4: Able to organize research information and data. CO5: Write and defend their research findings.
CEC593	CO1: Demonstrate and practice an effective communication skill through written and verbal to all levels of society. CO2: Demonstrate and exercise professional engineering practices and good working ethics. CO3: Demonstrate pleasant interpersonal skills as an individual or leader in working independently, collaborative and multi-disciplinary team. CO4: Demonstrate and practice Health Safety Environment (HSE) at the workplace. CO5: Demonstrate knowledge and need of sustainable development in professional practice.
CEC594	CO1: Generate key indicators and determinants to a complex engineering problem, and systematic approach towards its analysis and resolution. CO2: Propose a workable comprehensive design solution including comparable alternatives for an integrated design project using applicable guidelines, standards, specifications and/or manuals, and other accepted construction practices with an emphasis on integrating the broader analysis and design issues related to the structural and infrastructural project e.g. technical, economical, legal, ethical and socio-cultural concerns. CO3: Design qualified, and practical work processes involving improvised and ingenuous modern hardware and software combination to create and analyze representative models that would best simulate the behavior of complex engineering problems encountered. CO4: Develop professional ethics and sense of responsibility for societal, health, safety, legal and cultural concerns when dealing with or on issues affecting the professional community and the society at large. CO5: Unequivocally serve in collaboration with others in multidisciplinary teams in both leadership and subordinate roles with prescribed responsibilities for the purpose of producing of technical design specifications, presentation and defense of project findings. CO6: Develop comprehensive project construction scheduling and cost estimation based on real project scenarios and circumstances that would be realistic and implementable

METHODOLOGY

The POs attainment calculation methods used in the analysis for this paper were based on cumulative and culminating models. The cumulative model requires the calculation of POs from all related engineering courses throughout the entire program from the first until final year. In this model the average POs attainment is calculated including enabling and culminating courses. The enabling courses are practically used as the continuing measurement towards the students' POs attainment (Rohani et. al, 2017).

However, the culminating model calculation is based on selective courses that are normally arranged at the final year of the program. The culminating courses are basically selected as crucial courses that allow comprehensive analysis of actual POs attainment in evaluating students' knowledge and skills upon graduation. Three courses are

considered for the culminating model, i.e. Integrated Design Project (CEC594), Final Year Project (CEC591 and CEC592) and the Industrial Training (CEC593). The course outcome and program outcome (CO-PO) mapping for culminating courses are presented in Table 5. Basically, all POs are covered by the culminating courses to ensure actual POs attainment could be properly measured. The culminating courses might differ between universities as different courses could be selected in their culminating courses.

TABLE 5. CO-PO mapping for **c**ulminating courses for Bachelor of Engineering (Civil) Honors (Infrastructure)

Course Code	Course Name	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CEC591	FINAL YEAR PROJECT I	CO1		x										
		CO2									x			
		CO3		x	x									
		CO4												x
		CO5										x		
CEC592	FINAL YEAR PROJECT II	CO1					x							
		CO2								x				
		CO3		x		x								
		CO4											x	
		CO5									x			
CEC593	INDUSTRIAL TRAINING (* Part 6 and above)	CO1									x			
		CO2							x					
		CO3								x				
		CO4						x						
CEC594	INFRASTRUCTURE DESIGN PROJECT	CO1	x											
		CO2			x									
		CO3					x							
		CO4						x						
		CO5									x			
		CO6											x	

Equation 1 shows the calculation of PO attainment of individual students for cumulative model as well as culminating model. In culminating model calculations, only selected courses will be used in the equation.

$$PO_n = \left[\frac{(PO_nC_1 \; x \; ChC_1 \; x \; PO_nWC_1) + (PO_nC_2 \; x \; ChC_2 \; x \; PO_nWC_2) + (PO_nC_m \; x \; ChC_m \; x \; PO_nWC_m)}{(ChC_1 \; x \; PO_nWC_1) + (ChC_2 \; x \; PO_nWC_2) + (ChC_m \; x \; PO_nWC_m)}\right] \quad (1)$$

where,
PO_n = *PO attainment number*
PO_nC_m = *POn attainment score for course no. m*
ChC_m = *credit hour for course no. m*
PO_nWC_m = *PO weightage for course no. m*

For this study, all data was collected using an in-house developed program, designed to manage the OBE system. The POs attainment for all courses was compiled, uploaded and analyzed through our web-based system (POSCES). All data is accessible via the Civil Engineering Studies website.

The set of data used for the POs attainment analysis is based on a cohort of 226 students who graduated in September 2017. The numbers of students from diploma and matriculation intake were 115 and 111 respectively.

The enrollment from UiTM's diploma in Civil Engineering graduates will be given credit exemptions and begin their study at semester 3 compared to the enrollment from matriculation that will start from semester 1. Thus, we prepared a different dataset analysis to allow proper analysis of POs attainment. The analysis of POs attainments was calculated based on the courses of program structure with plan ID6116. The focus of POs attainment models' comparative analysis is to establish the reliability of methods and discuss the advantages and disadvantages of both models respectively.

RESULTS AND DISCUSSION

The POs attainment calculation based on cumulative model requires analysis of all engineering related courses from the academic program structure from year 1 to the final year. Therefore, the distribution of POs for each course must be well balanced to ensure an adequate and reliable analysis can be performed. In practical, at least three courses should be assigned for each designated PO.

Figure 2 until Figure 11 presents the data analysis of diploma graduate enrollment. Figure 2 and Figure 3 show the PO's attainment for cumulative average of PO attainment and percentage of students achieved at least 50% for civil engineering degree program for year one. Most courses in year 1 (semester 1 and semester 2) are mixed up of fundamental engineering courses, general studies (MPU) and servicing courses (fundamental sciences). Thus, only PO1 and PO2 were evaluated for POs attainment in year 1. The numbers of POs evaluated increased in year 2 as shown in Figure 4 and Figure 5. Compared to the year 1, more POs (PO1, PO2, PO3, PO7, PO9 and PO11) were evaluated in year 2 including affective domain and psychomotor domain.

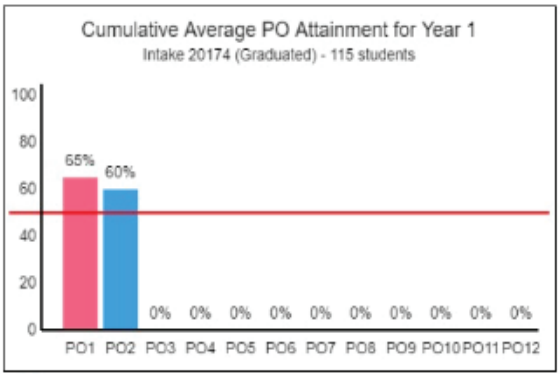

FIGURE 2. Average POs attainment for year ONE students of cohort 20174 (Diploma)

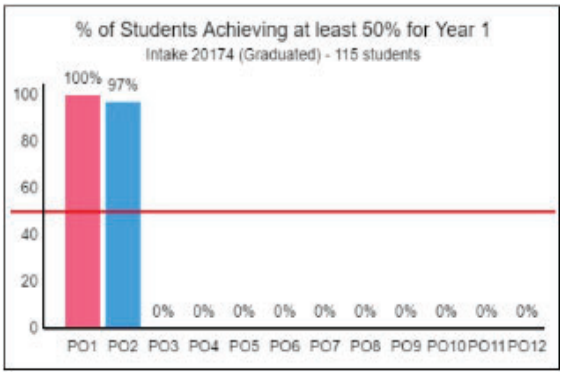

FIGURE 3. Percentage of students achieved at least 50% for year ONE POs of cohort 20174 (Diploma)

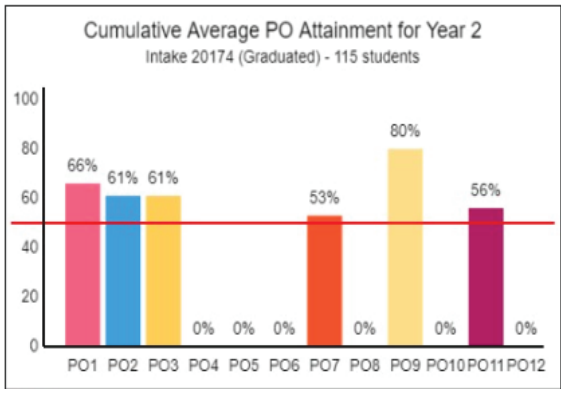

FIGURE 4. Average POs attainment for year TWO students of cohort 20174 (Diploma)

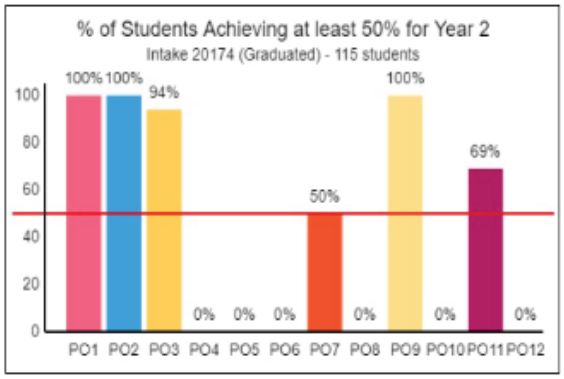

FIGURE 5. Percentage of students achieved at least 50% for year TWO POs of cohort 20174 (Diploma)

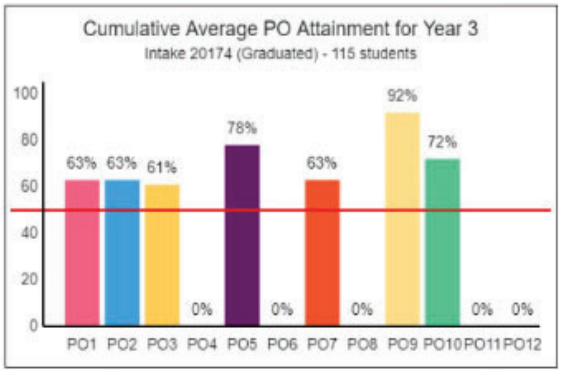

FIGURE 6. Average POs attainment for year 3 students of cohort 20174 (Diploma)

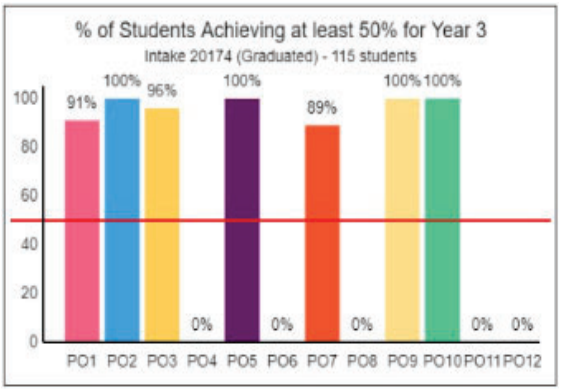

FIGURE 7. Percentage of students achieved at least 50% for year 3 POs of cohort 20174 (Diploma)

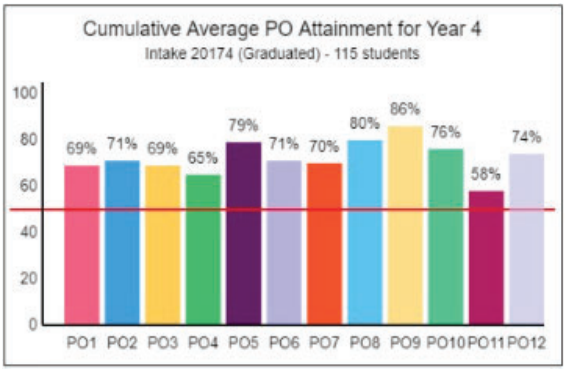

FIGURE 8. Average POs attainment for year 4 students of cohort 20174 (Diploma)

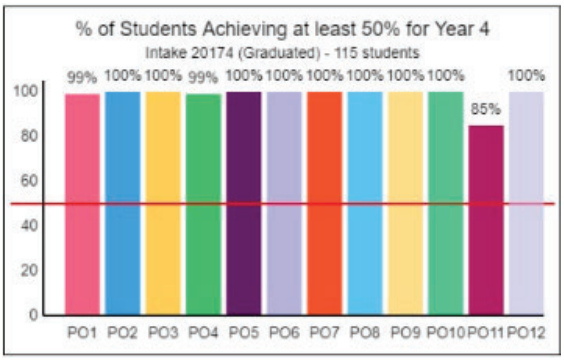

FIGURE 9. Percentage of students achieved at least 50% for year 4 POs of cohort 20174 (Diploma)

The evaluation of POs numbers increased in year 3 as shown in Figure 6 and Figure 7. The comprehensive analysis of POs attainment could be clearly seen when students reached their final year. A complete analysis of POs attainment was shown in Figure 8 and Figure 9. Figure 8 shows that the average value of students' attainment is above 50%. However, data in Figure 9 indicated that not all students achieved 50% of all POs. Due to the commitment of faculty to ensure all students achieve a minimum 50% of PO, an intervention program was conducted as CQI process to close the issue.

The POs attainment analysis based on cumulative model enables step by step observation of students' achievement from PO1 up to PO12 during the whole study period. The process of data input and continuous effort requires a consistent process to ensure that semester by semester analysis was performed. The cumulative model allows quick corrective measure taken if any of PO does not comply with the minimum requirements.

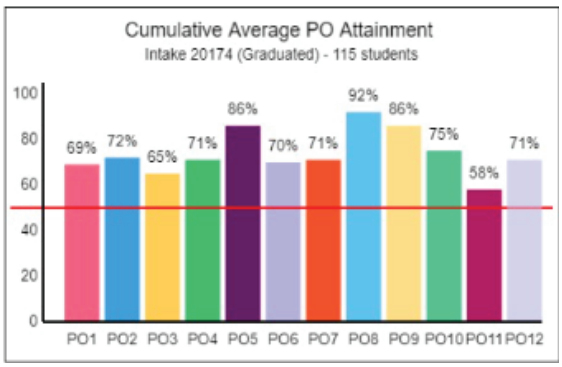

FIGURE 10. Average POs attainment for year 4 students of cohort 20174 (culminating model) (Diploma)

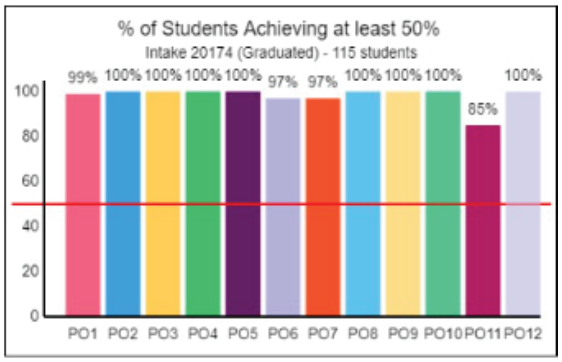

FIGURE 11. Percentage of students achieved at least 50% for year 4 POs of cohort 20174 (culminating model) (Diploma)

Figure 10 and Figure 11 present the POs attainment based on culminating models. In this POs attainment analysis, three courses that are considered for the culminating model are Integrated Design Project (CEC594), Final Year Project (CEC591 and CEC592) and the Industrial Training (CEC593). The analysis of POs attainment based on culminating model offers a simple process of data input and management. Based on Figure 8 and Figure 10, the culminating model allows a reliable POs attainment analysis.

Figure 12 to Figure 21 present the data analysis of matriculation student's enrollment. The total number of POs attainment for matriculation group in year 1 was six compared to only two for diploma intake group as shown

in Figure 12. This reflects the differences between the numbers of courses taken by matriculation and diploma group due to the credit exemption given to the enrollment of students from UiTM Civil Engineering Diploma graduate. The smaller gap of POs attainment numbers in year 2 and year 3 for diploma and matriculation group of enrolled students respectively. Comparison of data presented in Figure 4, Figure 6, Figure 14 and Figure 16 indicating both groups were on a similar track of academic structure. The achievement POs attainment of matriculation (Figure 19) and diploma (Figure 11) group at final year show the same performance with little differences for PO11.

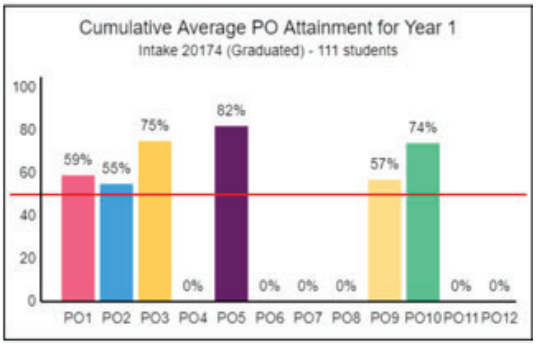

FIGURE 12. Average POs attainment for year 1 students of cohort 20174 (matriculation)

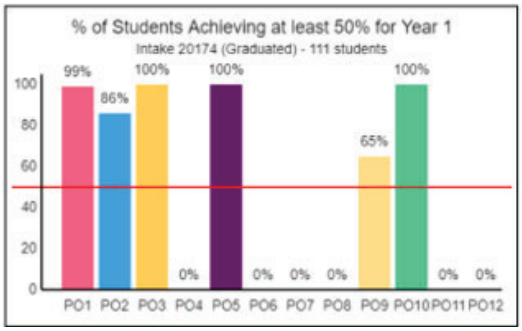

FIGURE 13. Percentage of students achieved at least 50% for year 1 POs of cohort 20174 (matriculation)

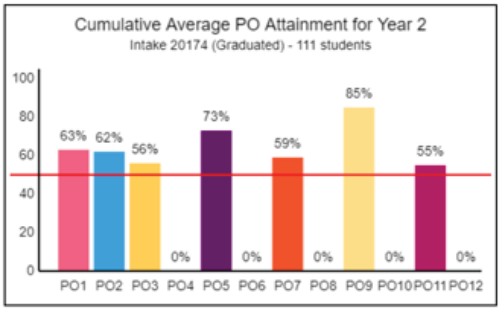

FIGURE 14. Average POs attainment for year 2 students of cohort 20174 (matriculation)

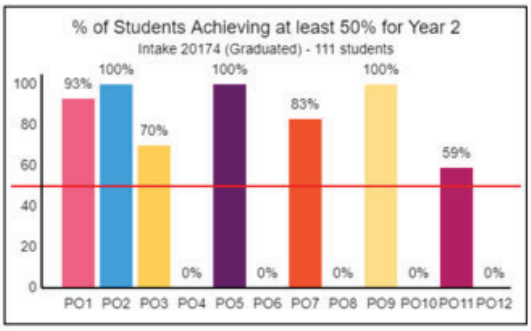

FIGURE 15. Percentage of students achieved at least 50% for year 2 POs of cohort 20174 (matriculation)

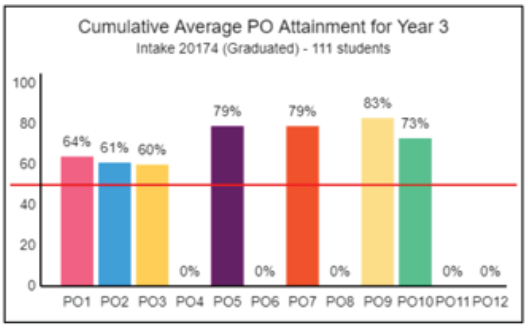

FIGURE 16. Average POs attainment for year 3 students of cohort 20174 (matriculation)

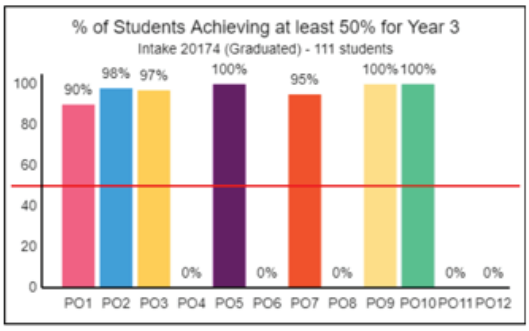

FIGURE 17. Percentage of students achieved at least 50% for year 3 POs of cohort 20174 (matriculation)

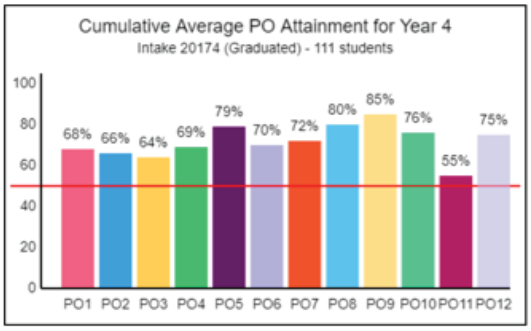

FIGURE 18. Average POs attainment for year 4 students of cohort 20174 (matriculation)

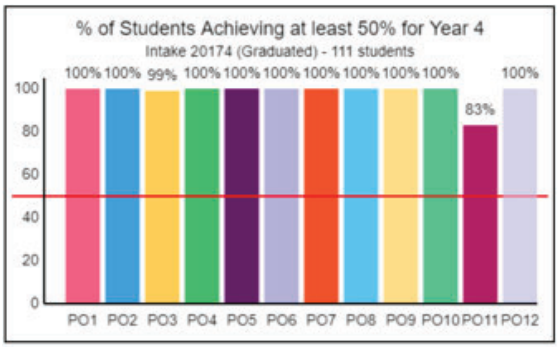

FIGURE 19. Percentage of students achieved at least 50% for year 4 POs of cohort 20174 (matriculation)

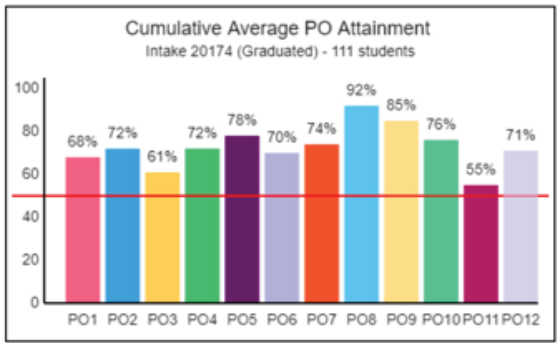

FIGURE 20. Average POs attainment for year 4 students of cohort 20174 (culminating model) (matriculation)

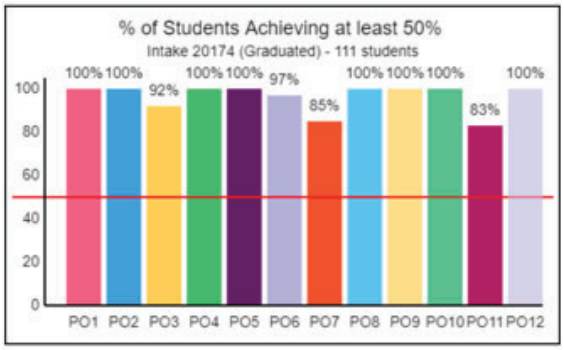

FIGURE 21. Percentage of students achieved at least 50% for year 4 POs of cohort 20174 (culminating model) (matriculation)

Direct comparison between cumulative model and culminating model confirms that both methods produced satisfactory POs attainment analysis. However, the culminating model is lacking in continuous monitoring process compared to the cumulative model. Any intervention measure due to unprecedented outcome of PO attainment cannot be performed at the early and middle stage of academic study period.

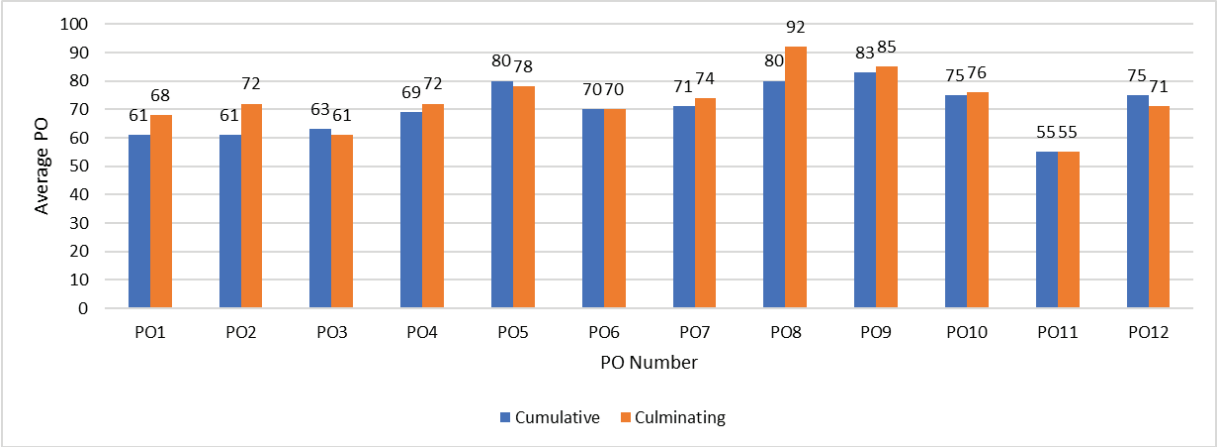

FIGURE 22. Average POs Attainment for cohort 20174 (matriculation)

The data in Figure 22 and Figure 23 show the average PO attainment of both models' evaluation for student cohort September 2017 – January 2018 (20174). The POs attainment presented was based on cumulative model and culminating model for both diploma and matriculation group respectively. The bar chart shows a slightly better overall average POs attainment percentage based on the culminating model compared to the cumulative model. The increases in average percentage of attainment for PO1, PO2, PO4, PO5, PO7, PO8 and PO11 are between 2% to 8%. The average percentage of attainments for PO9 and PO10 are the same for both models. However, a slight decrease was observed for PO3, PO6 and PO12 attainment based on culminating model compared with cumulative

model. This comparison indicates that the evaluation of POs attainment using culminating model and cumulative model matched well with only small differences between both models.

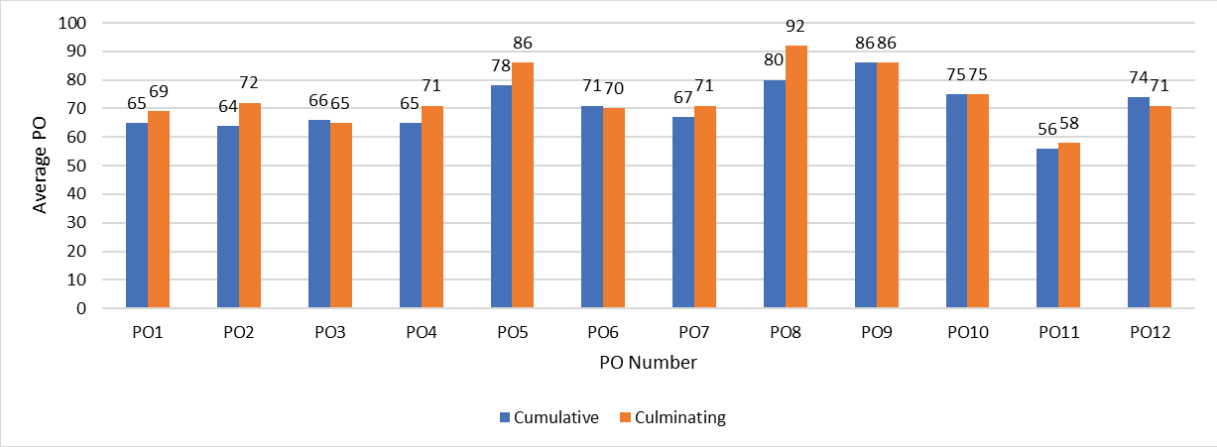

FIGURE 23. Average POs Attainment for cohort 20174 (Diploma)

TABLE 6. Percentage different between Accumulative model and Culminating model (diploma)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Cumulative Courses	61	61	63	69	80	70	71	80	83	75	55	75
Cumulative Courses	68	72	61	72	78	70	74	92	85	76	55	71
Percentage different	6.15%	12.50%	-1.52%	9.23%	10.26%	-1.46%	5.97%	15.00%	0.00%	0.00%	3.57%	-4.05%

TABLE 7. Percentage different between Accumulative model and Culminating model (matriculation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Cumulative Courses	61	61	63	69	80	70	71	80	83	75	55	75
Cumulative Courses	68	72	61	72	78	70	74	92	85	76	55	71
Percentage different	11.48%	18.03%	-3.17%	4.35%	-2.50%	-0.00%	4.23%	15.00%	2.41%	1.33%	0.00%	-5.33%

Table 6 and Table 7 tabulated the differences between each PO attainment for both diploma and matriculation group of students. The maximum difference from diploma group is 15% for PO8 and the no difference for PO9 and PO10. However, the maximum difference for matriculation group is 18% for PO2 and no difference for PO6 and PO11. The variation pattern in POs attainment was observed between both measurement models and different groups of enrollment students.

The statistical analysis of Table 6 reveals that the mean scores for the cumulative and culminating models are 70.58 and 73.83, respectively. A similar pattern is observed in Table 7, where the mean scores for the cumulative and culminating models are 70.25 and 72.83, respectively. These mean scores indicate that the culminating model tends to perform better on average compared to the cumulative model. The analysis of Table 6 shows an average percentage difference of 4.64% between the two models, with a standard deviation of 6.18%. Similarly, the analysis of Table 7 reveals an average percentage difference of 3.82% between the models, with a standard deviation of 7.36%. These values reflect the variability between the two models.

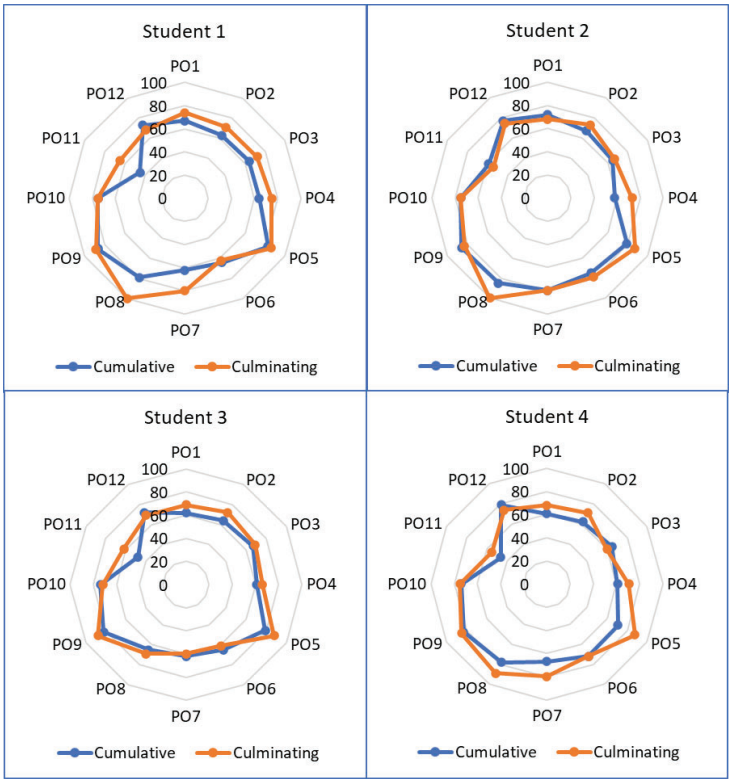

FIGURE 24. Individual Student Spider web on PO Attainment (Diploma)

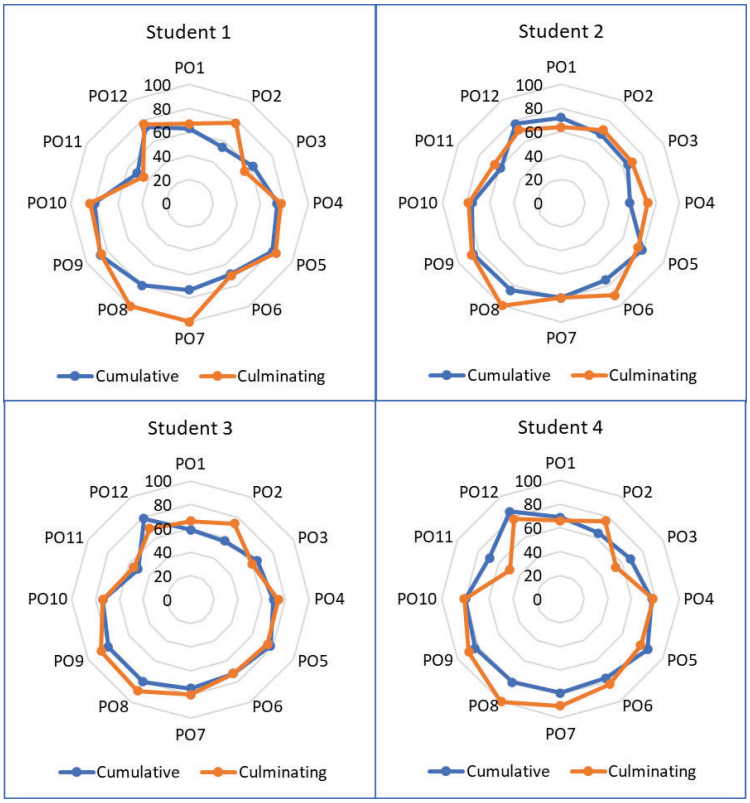

FIGURE 25. Individual Student Spider web on PO Attainment (matriculation)

Further comparison between different students' POs shows that both models are practically able to capture graduates' POs' attainment for the program. Figure 24 and Figure 25 show four different students' POs attainment evaluation using both models for diploma and matriculation group respectively. Analysis using culminating model (orange colour) shows overall better performance with slight differences compared to the cumulative model (blue colour). Individual POs attainment performance from spider web data presentation allows further comparison between the cumulative model and culminating model in PO attainment evaluation. The findings can consolidate the reliability of both measurement models in the evaluation of POs attainment and the capability of the program in producing graduates with the necessary attributes as stated in the accreditation manual or standard (Lee & Lee 2022).

The findings from the study on the reliability of Program Outcome (PO) attainment evaluation using cumulative and culminating models in engineering education can be generalized to other academic disciplines and institutions by emphasizing the adaptability of these models to various educational contexts. Both models provide systematic approaches to assess student competencies and program effectiveness, which are crucial for continuous quality improvement (CQI) in any discipline. By tailoring the specific outcomes and assessment methods to align with the unique attributes and goals of different programs, institutions can ensure that graduates meet the required competencies and standards (Victor et al, (2022). This adaptability supports the broader application of these models in diverse educational settings, promoting a consistent and reliable framework for evaluating educational outcomes and enhancing the overall quality of education across disciplines.

CONCLUSION

The culminating courses tend to have higher scores on average compared to cumulative courses across most performance objectives. This suggests that the culminating model may be more effective in achieving higher performance in these objectives. However, the variability in scores also indicates that there are differences in how students perform across different objectives, which could be explored further to understand the underlying factors.

The analysis of POs attainment data based on the accumulative courses model and culminating courses model data concludes that both methods are equally capable of capturing the graduate attributes of graduated students at the end of their study. Both models produce consistent results with small differences in certain POs attainment percentages that are acceptable. This finding is in-line with the continuous effort made by academicians and administrators of Civil Engineering Studies in continuous quality improvement (CQI) practices of OBE system.

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DECLARATION OF COMPETING INTEREST

None.

REFERENCES

Abbas, J., Kumari, K., Shah, M. A. & Golam, M. 2023. Graduate attributes for accreditation of engineering programs: Challenges and strategies. *Journal of Engineering Education* 112(1): 1-14.

Ali, Q. I. 2024 Towards more effective summative assessment in OBE: A new framework integrating direct measurements and technology. *Discover Education* 3(1): 107.

Asim, M. H., Vaz, A., Ahmed A. & Sadiq, S. 2021. A review on outcome based education and factors that impact student learning outcomes in tertiary education. *International Education Studies* 14(2): 1-11.

Engineering Accreditation Council. 2020. *Engineering Programme Accreditation Standard 2020.* Engineering Accreditation Council. https://eac.org.my/v2/wp-content/uploads/2022/09/EAC-Standard-2020.pdf

Gold, R. 2001. Evaluation of instruction. *Educational Studies* 15(1): 31-42.

Guggari, S., Okoye, K. & Abraham, A. 2023. *Review of Challenges and Best Practices for Outcome-Based Education: An Exploratory Outlook on Main Contributions and Research Topics.* In Innovations in Bio-Inspired Computing and Applications 649: 621-639.

Gurocak, H. 2009. Planning and implementing an assessment process with performance criteria for ABET accreditation. *International Journal of Engineering Education* 25(6): 1236–1248.

Ismail, R., Mohamad Nor, M. R., Mohd Ismail, A. M., Abdullah, N. H. H. & Ahmad, H. 2022. *OBE Implementation Manual 3rd Edition*. AnyFlip. https://anyflip.com/xagyg/efmw/basic

Jakhale, A. R. & Attar, A. C. 2015. A novel approach towards outcome based engineering education for continuous quality improvement: A case study. *Journal of Engineering Education Transformations* 29(2): 47–52.

Kumar, P. & Singh, V. 2019. Continuous quality improvement in engineering education: Implementation and evaluation. *Quality Assurance in Education* 27(3): 311-329.

Lee, H. & Lee, J. 2022. Enhancing engineering students' competencies through program outcome assessment. *International Journal of Engineering Education* 38(2): 523-532.

Liew, C. P., Puteh, M., Mohammad, S., Omar, A. A. & Kiew, P. L. 2021. Review of engineering programme outcome assessment models. *European Journal of Engineering Education* 46(5): 834–848. https://doi.org/10.1080/03043797.2020.1852533

Othman, N. M., Hasan A., Zakaria, A. F. & Bokhari, N. 2022. Job readiness elements for hospitality graduates: A pilot study. *Jurnal Kejuruteraan* 25(2): 233-236.

Qadir, J., Al-Fuqaha, A., Lim, K.-, Yau, A., Shafi, A., Taha, A.-E. M., Ponciano, J., Hussain, S., Imran, M. A., Sheikh Muhammad, S., Naveed Bin Rais, R., Rashid, M. & Tan, B. L. 2020. Outcome-based engineering education: A global report of international OBE accreditation and assessment practices. *2020 ASEE Virtual Annual Conference Content Access*. https://doi.org/10.35542/osf.io/rde62

Rajak, A., Shrivastava, A. K., Bhardwaj, S. & Tripathi, A. K. 2019. Assessment and attainment of program educational objectives for post graduate courses. *International Journal of Modern Education and Computer Science* 11(2): 26–32. https://doi.org/10.5815/ijmecs.2019.02.04

Rohani, R., Rahman, N. A., Masdar, M. S., Yuhana, N. Y., Abdullah, S. S., & Yusoff, I. I. 2017. Program outcomes for enabling and culminating course: Process system engineering and design project. *Journal of Engineering Science and Technology* 12: 31-41.

Santhi Rani, C., Raja Sekhara Rao, K. & Eliah, K. 2018. A simple approach to calculate CO and PO attainment levels by direct and indirect methods. *Journal of Emerging Technologies and Innovative Research* 5(12).

Sundararajan, K. & Gopalan, V. 2020. Comparative analysis of different assessment models in outcome-based education. *Journal of Engineering Education Transformations* 34(4): 5-14.

Victor G., Abdullah, S. & Affandi, H. M. 2022. The evolution of ignition pedagogical paradigm framework to engineering ethics education. *Jurnal Kejuruteraan* 5(2): 63-72.

Yamayee, Z. A. & Albright, R. J. 2008. Direct and indirect assessment methods: Key ingredients for continuous quality improvement and abet accreditation. *International Journal of Engineering Education* 24(5): 877–883.

Zamri, M., Mohd Yusof, T. & M.S. Reza. 2010. Assessment method for course outcome and program outcome in outcome based education (OBE). *Malaysian Technical Universities Conference on Engineering and Technology* 1–4.