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Analysis of program outcomes attainment for diploma in civil engineering at Universiti Teknologi MARA Pahang

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ABSTRACT

Analysis of program outcomes involves the assessment of the learning objectives based on cognitive, psychomotor, and affective domains and their attainment is measured using both direct and indirect approaches. This study aims to assess the program outcomes attainment for the civil engineering diploma program at Universiti Teknologi MARA Pahang. The program outcomes attainment in this study was obtained from two categories of students based on cohort 20174 using the Plan ID 6541, namely i) 257 graduated on-time students and ii) 365 overall students including extended students. The attainments were analyzed quantitatively using key performance indicators for each program outcome and program performance indicators for the overall attainment of program outcomes. Based on the key performance indicator, the results reveal that nine program outcomes are indicated as excellent while three program outcomes are indicated as good. Meanwhile, based on the program performance indicator, this cohort is indicated as well performed where 9 out of 12 program outcomes recorded above 70% average attainment. Various effective continuous quality improvement (CQI) program can be identified by the school's committee based on these findings to further enhance the program outcomes attainment.

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1. INTRODUCTION

Outcome based education (OBE) focuses more on the outcomes and the quality of graduates upon completion of their studies and allows the higher learning institution to enrich the value of the program by enhancing the learning capability of the students [1]. In order to create more graduates who fulfill the market demand, numerous assessment methodologies for courses have been devised and deployed in higher education [2]. Many studies has been carried out on the implementation of OBE in Malaysia context such as by using indirect measurement through survey with alumni from the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, program outcomes (PO) related to engineering knowledge and complex engineering design using direct measurement for final year students in the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, evaluation of the course learning outcomes (CLO) attained by engineering students in the Faculty of Electrical Engineering, UiTM, Shah Alam and student development progress and enhancement which the data is gained from the program outcome of diploma in civil engineering, UiTM Pulau Pinang [3]–[6].

Engineering plays a crucial part in boosting worldwide well-being thus it is the obligation for engineering education to remain relevant and effective [3]. The rapid speed of technological changes raises some issues in academia with regards to keeping the curriculum in line with the demands of the field,

ensuring that it is used effectively as well as improving its quality [7]. However, several opinions have been debated on the quality of university education systems due to the diversity of viewpoints and methodologies used to evaluate the effectiveness and standard of education [8].

Accreditation process is a formal form of confirmation that a program run by the respective higher learning institute meets the reputable standard of practice and is considered competent to carry out assessment thus producing quality of graduates and meeting a set level of competency which required by the employer and is one of the best ways to maintain the quality of the program [3]. Engineering Technology Accreditation Council (ETAC) which is located under Engineering Accreditation Department is the regulatory body that is responsible to accredit the technical programs in higher learning institutions in Malaysia [9]. The purpose of accreditation is to ensure that engineering programs satisfy the requirements of the Board of Engineers, Malaysia [9].

Course outcome (CO), PO and program educational objective (PEO) are phases of outcomes that need to be measured in OBE. The PEOs are broad statements that describe the future careers and professional accomplishments of those who had participated in the program after substantial years of study leading up to graduation. The POs are specific statements that explain the qualities that engineering program graduates should be able to have while the COs are statements about what outcomes a course should expect students to achieve [10]. Pramono *et al.* [11] stated that the CO is evaluated at the end of the course, the PO are evaluated upon graduation, and the PEO results are evaluated after three to five years from the date of graduation.

One of the main criteria under accreditation requirements is the measurement of program outcomes (POs) attainment. The POs for each program formulated by the higher learning institute must be consistent with the engineering graduate attributes, such as: i) engineering knowledge; ii) problem analysis; iii) design/development of solutions; iv) investigation; v) modern tool usage; vi) the engineer and society; vii) environment and sustainability; viii) ethics; ix) individual and teamwork; x) communication; xi) project management and finance; and xii) life long learning. These POs can be reached through course outcomes (COs) [9]. The following section will discuss the process involved in measuring the POs attainment.

2. PROGRAM OUTCOMES

The outcomes which students should have achieved by the time they graduate are known as POs. Program outcomes guides on what a program is supposed to do, achieve, or attain for its own betterment and/or in support of institutional or divisional goals, and are usually based on numbers, needs and growth. According to the ETAC manual, POs are statements that indicate what students are expected to know, be able to execute, or acquire by the time they graduate [7], [12].

A study reported that attributes in the PO are frequently linked to the education that the student has received. Every semester, the achievement of PO must be tracked, and corrective steps must be taken if the attainment does not match the performance indicator set for the program. This requires the implementation of continual quality improvement (CQI) method to improve the POs attainment. Based on this, if these processes are not conducted, then it is difficult for instructors to evaluate the problems that occur in the programs they offer [13]. Engineering technology accreditation council Malaysia, ETAC, provides rules for institutions to follow as to achieve academic excellence which then leads to accreditation. The curriculum and course outcomes are designed according to these guidelines. The program outcomes must precisely highlight the main components based on the goals of that program. Failures in curriculum design will result in misleading outcomes [7].

Rao stated that globalization demands mobility of engineering skills to ease utilization of technical skills from accessible locations, wherever necessary [14]. A strong foundation in mathematics and science, in addition to training in the various subfields of engineering, is an essential component of any education in engineering. In addition to this, he asserts that engineers will be able to deal with difficult probabilities and deliver complicated societal issues. Therefore, it is the responsibility of engineering educators to guarantee that students graduate with the knowledge and abilities necessary to pursue careers as successful professional engineers or technicians. This can be accomplished by abandoning the conventional approach to teaching in favor of an outcome-based education that places an emphasis on learning that is centered on the learner [14], [15]. Thus, the 12 POs for the diploma in civil engineering have been established to describe what the students should have learned and be able to accomplish by the time they receive their diplomas. These POs refer to the broad characteristics of knowledge (cognitive), skills (psychomotor), and behavior (affective) that students are required to acquire over the course of three years in completing an engineering technician diploma and detail of the 12 POs are listed in Table 1.

Table 1. Program outcomes for diploma in civil engineering program [9]

	Upon graduation, students should be able to
PO1	Apply knowledge of mathematics, natural science, engineering fundamentals, and civil engineering knowledge to wide practical procedures and practices
PO2	Identify and analyze well-defined civil engineering problems reaching substantiated conclusions using codified methods of analysis specific to the civil engineering activity.
PO3	Design solutions for well-defined technical problems and assist with the design of systems, components, or processes to meet civil engineering needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PO4	Conduct investigations of civil engineering's well-defined problems; locate and search relevant codes and catalogs for civil engineering, conduct standard tests and measurements that relevant for civil engineering
PO5	Apply appropriate techniques, resources, and modern engineering and IT tools to well-defined civil engineering problems, with an awareness of the limitations.
PO6	Demonstrate knowledge of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to civil engineering technician practice and solutions to well-defined civil engineering problems.
PO7	Understand and evaluate the sustainability and impact of civil engineering technician work in the solution of well-defined civil engineering problems in societal and environmental contexts.
PO8	Understand and commit to professional ethics and responsibilities and norms of civil engineering technician practice.
PO9	Function effectively as an individual, and as a member in diverse technical teams.
PO10	Communicate effectively on well-defined civil engineering activities with the engineering community and with society at large, by being able to comprehend the work of others, document their work, and give and receive clear instructions
PO11	Demonstrate knowledge and understanding of engineering management principles and apply these to one's work, as a member or leader in a technical team and manage projects in multidisciplinary environments
PO12	Recognize the need for and can engage in independent updating in the civil engineering technical knowledge.

The engineering program assesses and evaluates students on the knowledge and skills components. Thus, there are three classifications of the POs under cognitive domain, two POs under psychomotor domain, and seven POs under affective domain. The cognitive domain is a thinking domain that relates to how to utilize knowledge, focusing on intellectual skills. While the physical and kinetic abilities that can be monitored throughout the progressive of mastery the physical skills are represented by the psychomotor domain. Affective domains deal with how one feels about things (attitude), which can be communicated through one's thoughts and beliefs. The attitude component is assumed to have been acquired once students complete the program and it is not explicitly assessed. Hence, to reduce the discrepancies in the assessment of soft skills, the standardized assessment rubrics such as communication, teamwork, leadership, lifelong learning, and ethics are provided [4]. Table 2 shows the classification of the POs according to Bloom's three main domains.

Table 2. Classification of POs into bloom's domains

Bloom's domain	Program outcomes
Cognitive	PO1, PO2, PO3
Psychomotor	PO4, PO5
Affective	PO6, PO7, PO8, PO9, PO10, PO11 and PO12

2.1. Way of program outcomes assessment and evaluation

Testing, assessment, and evaluation are the notions that are strongly tied to educational measuring. All educational assessments attempt to i) reach acceptable conclusions about students' aptitude, achievement, or interests; ii) track student's progress toward specific educational goals; and iii) improve teaching and learning [16]. Assessment tools for measuring POs can be divided into direct and indirect methods. The evaluation of outcomes that is based on direct assessment is more appropriate since it evaluates the specific knowledge or abilities of the students in a more direct manner. The direct method assessment is through final examination, tests, practical tests, assignments, projects, presentations, and others. For psychomotor assessment, the assessment tools are normally hands-on, which introduce the students to the real engineering practice [17].

The assessment is formulated corresponding to the designated POs for the course. The indirect methods, including the external examiner reports, feedback from industrial advisory panels and industrial training surveys, provide an insight on the effectiveness of the program in developing graduate attributes manifested in the POs. When each semester is over, the contribution from all the types of assessment can be used to measure each PO by having the average PO and these results are utilized to compile an annual report evaluating overall program outcomes [4]. Table 3 shows various assessment tools for measuring POs of diploma in civil engineering courses.

Table 3. Assessment tools for measuring POs

PO	Domain	Assessment tools	
		Direct	Indirect
PO1	Cognitive	Assignment/Project report, test, and examination	External examiner's report
PO2			Industrial advisory panel
PO3			Industrial training survey
PO4	Psychomotor	Practical tests, Civil engineering	
PO5		Design project, Industrial training	
PO6	Affective	Laboratory report, Lab observation,	
PO7		Assignment/Project, Oral presentation	
PO8			
PO9			
PO10			
PO11			
PO12			

2.2. Evaluation of the program outcomes

The evaluation of POs is based on bloom's domain and taxonomies as shown in Figure 1 to indicate the approach that has been adopted in developing methods of assessment and evaluation of POs. There are three approaches that have been adopted such as classification of POs into Bloom's domains, development of performance criteria matrix and development of strategies/action. All these approaches are to make sure the assessment and evaluation are fair and aligned with the designed POs.

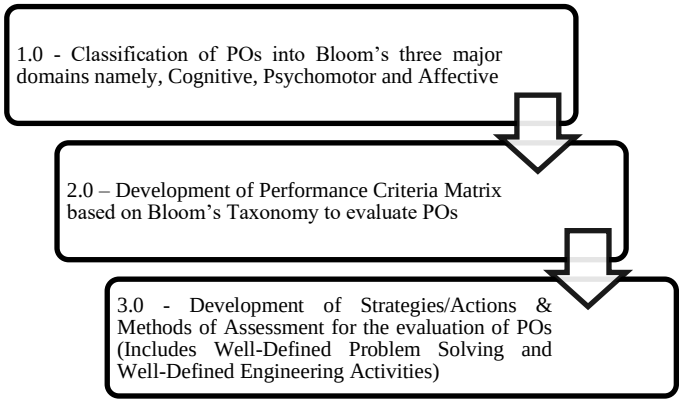

Figure 1. Approach adopted in developing methods of assessment and evaluation of POs

2.3. Determination of program outcomes attainment

The accumulating model is used to determine the PO attainment for this diploma program, in which all courses contributing to the POs attainment are considered in the calculation. The assessment method includes student's works and other tangible materials that demonstrate achievement of the POs. Each individual course's associated POs that need to be measured are mapped to the respective Course Outcomes. Table 4 illustrates the distribution of POs i.e., PO1 and PO3 based on the assessments in Basic Hydraulics whilst Table 5 illustrates an example attainment of PO1 and PO3 for two students: Student ID 1 and Student ID 2. This example was determined by the respective scores they obtained in the Basic Hydraulics course and the sample of calculation to determine the true attainment of PO1 and PO3 for this course for Student ID 1 is presented next after Table 5.

Table 4. Distribution of POs for basic hydraulics course addressing PO1 and PO3

Assessment	POs	Full marks	Weightage
Assignment 1	PO1	100	7%
Assignment 2	PO3	20	3%
Common Test	PO1	10	6%
	PO3	40	24%
Final Exam	PO1	19	11.4%
	PO3	81	48.6%
Total	PO1	-	24.4%
	PO3	-	75.6%

Table 5. Example calculation for PO1 and PO3 based on individual students' marks in basic hydraulics

Assessment	POs	Full marks	Student ID 1	Student ID 2
Assignment 1	PO1	100	80	60
Assignment 2	PO3	20	15	18
Common test	PO1	10	6	5
	PO3	40	29	18
Final exam	PO1	19	12	11
	PO3	81	62	35
PO Attainment (%)	PO1	-	67.2	56.6
	PO3	-	75.2	45.6

PO1 attainment by the first student (student ID 1) is calculated as (1).

$$PO1 = \frac{80}{100}(7\%) + \frac{6}{10}(6\%) + \frac{12}{19}(11.4\%) = 16.4\% \quad (1)$$

Therefore, the true attainment of PO1 is calculated as (2).

$$PO1 = \frac{16.4}{24.4}x100\% = 67.2\% \quad (2)$$

Meanwhile, PO3 attainment by the first student (student ID 1) is calculated as (3).

$$PO3 = \frac{15}{20}(3\%) + \frac{29}{40}(24\%) + \frac{62}{81}(48.6\%) = 56.85\% \quad (3)$$

Therefore, the true attainment of PO3 is calculated as (4).

$$PO3 = \frac{56.85}{75.6}x100\% = 75.2\% \quad (4)$$

The calculation is then applied to the other students who enrolled for the basic hydraulics course, for example 75 students. Then PO attainments for all students are added and divided by 75 to obtain the average PO attainment for the course. To properly assess PO attainment for the program, a methodology for evaluating performance that is based on each PO as a main thrust and includes specific criteria for performance is being developed. It is essential, however, that the knowledge or abilities of the students that are reflected in a score or grade serve as the primary focal point, and not the grade itself [18], [19]. This is agreed by Telsang that designing delivery and assessment to suit the outcomes of the program are challenging but measuring and redefining the student's achievement are more complicated [20].

Some programs might use the 70% determination value to determine the satisfaction criterion to decide whether POs meet expectation or not. Then, if the program outcomes have low assessment values, the program needs backtracking to point out their shortages [21]. The teaching and learning process is continued if the correlation is high enough to satisfy expectations; otherwise, it is adjusted to raise the level of attainment [22]. Wahab *et al*. has conducted a study at the Department of Electrical and Electronic that shows the element of POs direct assessment instrument that is based on the knowledge and skills of students. They used the average POs data obtained from all the selected courses to evaluate overall achievement of POs and the findings suggest that every PO is successful in exceeding the predetermined score for the respective academic year [23]. In the same vein, the objective of this paper is to assess the POs attainment for the diploma in civil engineering program at UiTM Pahang. Moreover, the purpose of this study is to fulfill the respective research questions:

i) Can the program demonstrate whether students have obtained the desired score?
ii) How does the course grade conceal precise achievement of the anticipated criteria?
iii) Can students demonstrate an acceptable level of performance in each program outcome?

3. RESEARCH METHOD

The program outcomes (POs) attainments were collected from summative assessments throughout student enrolment for six semesters. The marks were collected from various types of assessments as shown in Table 3 gathered for all courses based on the accumulating model. The performance criteria are categorized into two: i) key performance indicator (KPI) for each PO; and ii) program performance indicator for overall PO attainment (number of POs achieve average 70%). The KPI for each PO is categorized based on the PO Score for each PO. As shown in Table 6, the KPI is classified as excellent when the average PO score is 70%

and above, good when the PO score is 50% to 69% and fail when the PO score is below 50%. This indicator reflects the need for intervention programs for continual quality improvement of the program.

Table 6. Program outcomes attainment through formal assessments

Key performance indicator for each PO	
PO score (%)	KPI category
70 - 100	Excellent
50 - 69	Good
0 - 49	Fail

Meanwhile, for the program performance indicator, the overall POs attainment was calculated based on the numbers of PO that achieve an average of 70%. The program is classified as well performed if 9 to 12 PO achieves 70%, performed if 4 to 8 PO achieves 70% and concern if it is less than that. Table 7 shows the details.

Table 7. Program performance indicator for overall POs attainment

Overall PO attainment (number of PO achieve average 70%)	
Indicator	No. of POs
Well performed	9-12
Performed	4-8
Concern	0-3

4. RESULTS AND DISCUSSION

4.1. Analysis on program outcomes achievement

The data presented in Figure 2 are based on the analysis of PO attainment for cohort 20174 (September 2017) which is the first batch using the Plan ID 6541 at UiTM Pahang that has been accredited by ETAC. Students were analyzed based on two categories: i) students who graduated on time (GOT) and ii) overall students (GOT plus the extended students). There were 257 out of 365 students, or 70.4% able to GOT, while 365 students are in second category.

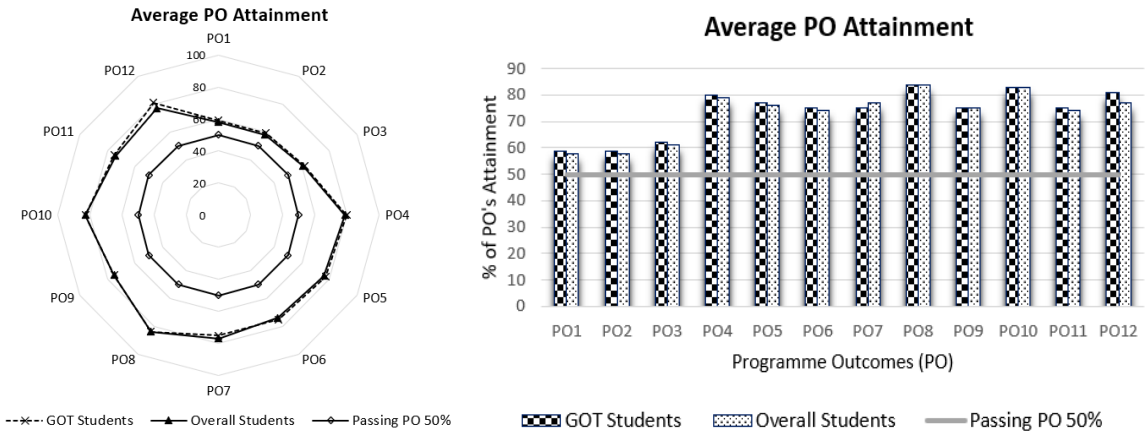

Figure 2. Average PO attainment for GOT (70.4 %) and overall students from 20174 cohort

The highest PO attainment for both categories is PO8 (understand and commit to professional ethics and responsibilities and norms of technician practice) which recorded a score of 84% for both. While the lowest PO attainment is PO1 (Apply knowledge of mathematics, natural science, engineering fundamentals, and civil engineering knowledge to wide practical procedures and practices) and PO2 (Identify and analyze well-defined civil engineering problems reaching substantiated conclusions using codified methods of analysis specific to the civil engineering activity). For GOT students, they score 59% for both PO1 and PO2, while for overall students, the attainment is 58% for both POs. The other POs are at the range of 61% - 83%.

The positive aspect is all the POs are above 50% marks, which achieve the KPI. Therefore, this information provides a sight to the department to identify the possible roots which contributed to this lacking, which is knowledge and problem analysis, thus can proceed with CQI actions to improve students' performance for the upcoming semester.

Table 8 provides the value of program outcomes attainment for both categories of students, and the data is separated according to domains which are cognitive, psychomotor, and affective. For GOT students, the highest attainment is dominated by the psychomotor domain with an average of 78.5%. Whereas, for the overall cohort, the highest attainment is from the affective domain with 77.7%. However, both categories share the lowest domain which is cognitive. The cognitive courses which cater PO1 and PO2 are introduced in the first year of study. The progression was made for cognitive domain concentrated in PO3 at the second and third year. The other POs, PO4 to PO12 are assessed mostly in the second and third year. The results showed that students' progression is due to experience, maturity, and familiarity with university systems. The program has a lot of hand-on assessments in the laboratory and field work, therefore, higher marks in psychomotor are anticipated. Thus, this is aligned with the expectation that technical graduates need to complement their technical knowledge and awareness on the professional standard, environmental and societal demands [24], [25].

Table 8. POs attainment for 20174 students

Bloom's domain	GOT students of 20174 cohort			Overall students of 20174 cohort		
	C	P	A	C	P	A
PO1	59			58		
PO2	59			58		
PO3	62			61		
PO4		80			79	
PO5		77			76	
PO6			75			74
PO7			75			77
PO8			84			84
PO9			75			75
PO10			83			83
PO11			75			74
PO12			81			77
Average (%)	60.0	78.5	78.3	59	77.5	77.7

Based on the key performance indicator for each PO, nine POs are indicated as excellent (70%-100%) while three POs are indicated as good (50%-69%). This cohort is indicated as well performed where 9 out of 12 POs achieve above 70% average attainment. With a more detailed analysis at individual level, the management can identify the specific students with low performance of POs. From that, suitable intervention programs at individual, course, and program level such as workshops to enhance students' soft skills can be implemented as the CQI program. As an alternative, students of diploma in Civil Engineering at Universiti Teknologi MARA Pahang can also assess their individual PO attainment for self-monitoring and improvement.

4.2. Comparison with similar research

Thakkar and Landge [26] conducted a study that examined the use of direct and indirect methods to assess the attainment of PO for engineering program accreditation. It provides teaching faculty with the opportunity to identify gaps and take appropriate measures to enhance the overall proficiency of the learners. Amirtharaj *et al*. [27] conducted additional research that demonstrated the implementation of a systematic assessment approach to achieve a thorough evaluation in an engineering college. The findings from this study informed decisions and initiatives aimed at enhancing the program. The effective utilization of suitable strategies, such as setting and refining objectives and outcomes, as well as evaluating the achieved outcomes, not only ensured quality assurance and accreditation but also yielded various other advantages.

Rajak *et al*. [28] conducted an evaluation of PO and PEO using both direct and indirect assessment tools. Their study recognized the value of such assessments in validating students' performance and their contribution to program accreditation. Furthermore, the findings highlighted the importance of these assessments in meeting the requirements set forth by various government bodies for program assessment and accreditation. Researchers also explored the utilization of PO attainment to redesign CO and PO, aligning them with the evolving industry demands [29]. Numerous engineering institutes employ direct quantitative measurements of PO that are connected to the graduate attributes (GA). By utilizing various assessments, this measurement approach facilitates the continuous monitoring of students' GA attainment until graduation.

This systematic process allows for the implementation of intervention programs before graduation, aiding students in achieving the desired GA by the conclusion of their academic journey [30]. The finding from this study on the need for PO attainments analysis is aligned with previous studies conducted by different researchers, albeit the differences in approaches. Providing credential data of POs are crucial to represent students' performances and been used for instance; i) program accreditation from relevant agencies; ii) to assess student performance; iii) provide suitable intervention program for students; and iv) data to support review or redesign existing curriculum.

5. CONCLUSION

The PO attainment for diploma in civil engineering students for cohort 20174 using Plan ID 6541 at Universiti Teknologi MARA Pahang meets the performance standards requirement based on the key performance indicator and program performance indicator. Attainment in PO8 is dominant, compared to other POs for both GOT and overall students categories. The achievement of PO1 and PO2 for both categories of students was found to be the lowest. The findings of this study not only can be used to identify which domain and elements that need to be improved, but it also can be used as an indicator of whether the diploma in civil engineering program has met the requirements set by ETAC. The overall POs attainment can serve as a benchmark to the next cohort. Besides, from the program administrator perspectives, they must ensure that the program remains relevant, aligned with the national inspiration and meet the current market demand hence the sustainability of the program can be maintained.

There is a limitation that should be considered in this study in the aspect of data collection which relied solely on the data from the 20174 cohort. Therefore, a detailed study involving more cohorts is required so that the PO attainment trends for the civil engineering diploma program can be presented in a more comprehensive manner. Furthermore, it is suggested that future research endeavors in evaluating the PO attainment to investigate in-depth the PO attainment based on the gender of students. Additionally, exploring alternative methods of analysis such as statistical techniques or modern tools to assess the overall achievement of PO is recommended. The future researchers can also assess CO and learning outcomes data to make important decisions that can enhance the quality of the program.

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