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Unified Method for Evaluating the Outcomes of Academic BSc Engineering Programs for Different Accreditation Systems

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Abstract: This study critically evaluates a methodology proposed to standardize academic program evaluation of its learning outcomes, illustrating its implications for compliance with accreditation bodies like the Accreditation Board for Engineering and Technology, Inc. (ABET) and the Saudi National Center for Academic Accreditation and Evaluation (NCAAA). The varying requirements, terminologies, and phrasing of learning outcomes across accrediting bodies often increase workload and complexity for faculty and staff. To mitigate these challenges, the study proposes a cohesive methodology that standardizes the assessment process by deconstructing broad learning outcomes into specific, focused, and measurable performance indicators (sub-learning outcomes) that can then be easily linked to the proposed set of learning outcomes, which are in turn aligned with the applicable accreditation system. This approach was implemented at Qassim Engineering College, which simultaneously adheres to ABET and NCAAA requirements. The results demonstrate the framework's efficacy, showing a significant reduction in effort and time required for assessment, along with improved precision in identifying shortcomings in learning outcomes. Ultimately, this integrated system acts as a strategic tool for institutions striving to enhance their educational quality, while satisfying the rigorous needs of various accreditation agencies. The study supports the wider adoption of standardized evaluation methodology to systematically improve the educational quality and guarantee compliance within the increasingly complex panorama of the accreditation of higher education.

Keywords*:* Learning Outcomes; Accreditation; Quality Assurance; Accreditation Criteria; ABET; NCAAA; Faculty Workload; Assessment Process; Educational Quality.

1. INTRODUCTION

Engineering education seeks to cultivate and amalgamate engineering principles, competencies, and both interpersonal and technical skills [1-3]. A multitude of universal institutions are offering engineering education, which is always evolving to address the escalating problems of advanced engineering ideas and the demands of the global economy [4-9]. It is imperative to regulate the quality of this education; this is accomplished by establishing a continuous improvement procedure [10-13].

Accreditation is a scheme for academic quality inspection. Accreditation needs strategies and activities of educational institutions or programs to be evaluated by an independent agency, either international or national, to determine if specific standard criteria are achieved [14, 15]. If those criteria are successfully fulfilled, accredited status is granted by the agency.

ABET Organization is one of the most famous international agencies which evaluate the academic engineering and technology programs, and offer accreditation certificates to them [16, 17]. In Saudi Arabia, the National Center of Academic Accreditation and Evaluation (NCAAA) is a national agency which works under the umbrella of the Education and Training Evaluation Commission (ETEC) as an independent agency for evaluating and ac-crediting the academic institutions and programs [18].

To satisfy the programs' stakeholders (constituencies) and accreditation agencies, the programs should have an assessment and evaluation method integrated in a continuous improvement process [17] to ensure the suitability of the program mission, program goals and the educational objectives in addition to checking and ensuring the achievement of a set of outcomes. The outcomes should be set to satisfy the conditions of the accreditation agency [17, 18]. The continuous improvement process should make use of the evaluation results by taking improvement actions [10-13].

Many authors have presented methods and techniques for measuring and evaluating the level of attainment of the objectives and learning outcomes of different academic programs. Abu-Jadail et. al. [19] presented a method to assess the learning outcomes of chemical and petroleum programs. The method depends on limited direct tools, and other indirect tools. It does not monitor the outcomes formation process during the study period. Rompelman [20] uses the outcomes assessment for short-term feedback actions for the assessment procedure, the activities of the students and the activities of the teacher, and long term actions for the objectives. Shuman et al. [21] explained how to help the students in acquiring the professional skills required by the ABET, and how to assess them. However, the study did not suggest a clear and reliable system for evaluating the outcomes. Loughry, et al. [22] developed a theory-based assessment of teamwork effectiveness through opinion surveys followed by exploratory- and confirmatory-factor thorough analysis to identify the proper tool items. The evaluation concentrated on evaluating the teamwork outcome only. Abigail Panter, et al. [23] suggested an assessment plan for the student outcomes. The plan contains: identifying some of the most significant outcomes, designing of direct assessment tools for each learning outcome, choice of the element of the academic plan in which the outcome will be assessed (course, internship, capstone course, etc.), type of work products that will be assessed (exam. papers, presentations, functioning, etc.), how the work will be evaluated (through rubric [24-26], by external reviewers, etc.), and the criteria that would be implemented to indicate success or the need for action. Indirect assessment methods can be included along with direct methods.

The article stressed that the plan should specify when to conduct each assessment and over what period. Alyheya, et al. [27] explained the experience of Qassim Engineering College (QEC) got from its first accreditation process. The evaluation system presented in the article has some shortcomings as it overloads the staff through repeating the assessment every semester. The presented method mixes assessment of students not belonging to the same batch. Quipmo [28] introduced the procedure steps to cure the weaknesses identified in the curriculum of Water Resources Program at Pittsburgh University. Seber et al. [29] showed the inconsistences at the start of preparing for the ABET review of software engineering and other engineering specialties. Ikbal, et al. [30] presented procedures of preparing and qualifying an engineering program for ABET accreditation, and applied it to Civil Engineering Program in King Saud University. Ivan Cabezas [31] stressed that engineering programs targeting an initial accreditation by the ABET should focus on what the students have acquired rather than what the instructor has delivered.

The present article suggests and applies to a developed outcomes evaluation technique suitable for the academic programs which must apply for accreditation by more than one accreditation agency. To minimize the effort required from the faculty, and to avoid duplication of the work, the outcomes evaluation will be carried out through developed performance indicators which may be linked to a set of learning outcomes (SOs for ABET proto col, for example) and another set of learning outcomes (PLOs for NCAAA protocol, for example).

QEC at Saudi Arabia has targeted the international accreditation of its BSc programs by the ABET organization in parallel and at the same time the national accreditation by the NCAAA. The suggested unified evaluation method has been applied

to the engineering pro-grams of the College. The method, its procedures and results of application regarding the learning outcomes for the Electrical Engineering (EE) BSc Program- as an example - will be presented in this paper. The benefits gained of using the suggested method regarding accuracy and effort saving will be highlighted.

2. MATERIALS AND METHODS

2.1. ABET Student Outcomes

The Engineering Accreditation Commission (EAC) of ABET defines student outcomes (SOs) as precise statements outlining the technical knowledge and understanding, skills, and values that students are anticipated to acquire by the time of graduation [17]. These out-comes function as quantifiable markers of a student's preparedness to join the engineering profession, including a broad spectrum of abilities necessary for successful practice in the area. The Quality assurance unit in college of engineering at QEC has implemented the seven recommended ABET EAC student outcomes for all three Bachelor of Science (BSc) engineering programs, in accordance with these standards [35-37] as detailed in Table 1. This adoption signifies a commitment to ensuring that graduates fulfill globally recognized standards for engineering education.

The ABET EAC outcomes that have been chosen to cater to a wide range of educational objectives, integrating a variety of competencies, such as technical knowledge, applied skills, core competencies, and ethical values. The QEC seeks to provide students with technical competency, critical thinking, problem-solving skills, collaborative capabilities, and an awareness of professional and ethical responsibilities via this comprehensive approach.

This organized amalgamation of knowledge, skills, competences, and values forms the foundation of curriculum design and evaluation procedures within the institution's BSc pro-grams, offering a solid framework to equip graduates for the requirements of the worldwide engineering profession.

Table 1: The adopted ABET SOs for all engineering Programs at Qassim University's College of Engineering [16].

SO_ #	Statement of Student Outcomes
SO_1	An ability to identify, formulate, and solve complex Eng. problems by applying principles of engineering, science, and mathematics.
SO_2	An ability to apply Eng. design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global cultural, social, environmental, and economical factors.
SO_3	An ability to communicate effectively with a range of audiences.
SO_4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judg-ments, which must consider the impact of engineering solutions in global, economic, environmental, and societal con-texts.
SO_5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
SO_6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judg-ment to draw conclusions.
SO_7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2.2. NCAAA Program Learning Outcomes

In accordance with the standards established by the National Commission for Academic Accreditation and Assessment (NCAAA) in Saudi Arabia, every academic program is mandated to formulate its own program-specific learning outcomes that must correspond with the Saudi National Qualifications Framework (NQF) [18].

This framework aims to guarantee that educational programs nationwide adhere to uniform standards of quality and rigor, while also being flexible enough to accommodate the distinct objectives and requirements of each program. The NQF categorizes Program Learning Outcomes (PLOs) into three main domains: knowledge and understanding, skills, values and responsibility.

The domains represent a systematic method for delineating the competencies anticipated of graduates. The domain of 'knowledge and understanding' includes essential theories, principles, and information pertinent to discipline. The 'skills' domain emphasizes the application of knowledge, encompassing analytical abilities, technical proficiency, and problem-solving skills essential in professional settings. The 'values and responsibility' domain underscores ethical principles, personal accountability, and social responsibility, promoting responsible actions among graduates in professional and societal contexts.

The NCAAA's framework distinctly categorizes learning outcomes to prevent overlap across domains, in contrast to the ABET Engineering Accreditation Commission's Student Outcomes, which often integrates multiple competencies from various areas, such as technical skills and ethical responsibility. This separation guarantees that the learning outcomes for each domain are specifically tailored, facilitating a clearer and more focused assessment of students' achievements in each area.

The QEC has established PLOs for all BSc programs in accordance with NCAAA requirements, categorized into three suggested learning domains, as detailed in Table 2.

Table 2: Established Program Learning outcomes (PLOs) for Electrical Engineering Program, at Qassim University's College of Engineering [38].

PLO_ #	Domain	Statement of Program Learning Outcome
K_1	**Knowledge and understanding**	Recall knowledge of Basic sciences (math, physics, management, economy, etc.) and Basic Engineering sciences.
K_2		Relate knowledge of Math, Statistics, basic sciences to electrical engineering specialization, together with in-depth knowledge of that specialization.
K_3		Comprehensively Identify research and inquiry methodologies
S_1	**Skills**	Formulate complex electrical engineering problems by applying principles of engineering, science, and mathematics.
S_2		Apply appropriate engineering techniques, and modern IT tools, including prediction and modeling of electrical engineering devices/equipment/components/systems to assess their characteristics and operation performance.
S_3		Design a device/component/equipment/system or process related to the electrical engineering field.
S_4		Communicate effectively, both orally and in written form using appropriate media, on complex engineering activities with the engineering community and with society.
S_5		Conduct inquiries, investigations, and research for complex issues and problems.
S_6		Investigate various electrical engineering problems through developing and conducting experiments, analyzing, interpreting data, and synthesizing of information to provide valid conclusions.
V_1	**Values**	Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
V_2		Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological changes.
V_3		Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

The implementation of shared structures of PLOs across all programs enhances the coherence of the engineering curricula and ensures that graduates possess a core set of capabilities valued by employers and aligned with international accreditation standards.

3. OUTCOMES ASSESSMENT AND EVALUATION APPROACHES

These Learning outcomes (either SOs for ABET or PLOs for NCAAA) are generally assessed using a combination of direct and indirect evaluation methods, facilitating a thorough comprehension of student performance and program efficacy [39-41]. Direct assessment methods entail the evaluation of student performance through specific tasks, assignments, exams or projects that are directly aligned with the intended learning outcomes. Assessments may be conducted in junior-level courses and selected senior-level courses, where students exhibit competencies directly related to the specified outcomes. The Senior Design Project (SDP) is a notable direct assessment tool that functions as a culminating experience, necessitating students to utilize their technical and professional skills in a practical, real-world context. Field Training offers direct insight into students' capabilities to operate effectively in a professional setting, thereby connecting academic knowledge with practical application.

Indirect assessment methods collect feedback regarding students' perceived learning experiences and self-assessed competencies, providing a complementary viewpoint to direct evaluations. Indirect methods encompass instruments like student course surveys, which allow students to evaluate the effectiveness of specific courses in enhancing their comprehension and skills. Field training surveys collect data from students and supervisors regarding the relevance of students' academic preparation in practical environments. The senior exit survey similarly captures graduating students' perceptions regarding their overall educational experience, including self-reported proficiency in essential competencies. In addition to this indirect evaluation, feedback and opinions are also gathered from the professional advisory board, student advisory committee, and external visitors, as depicted in Figure 1.

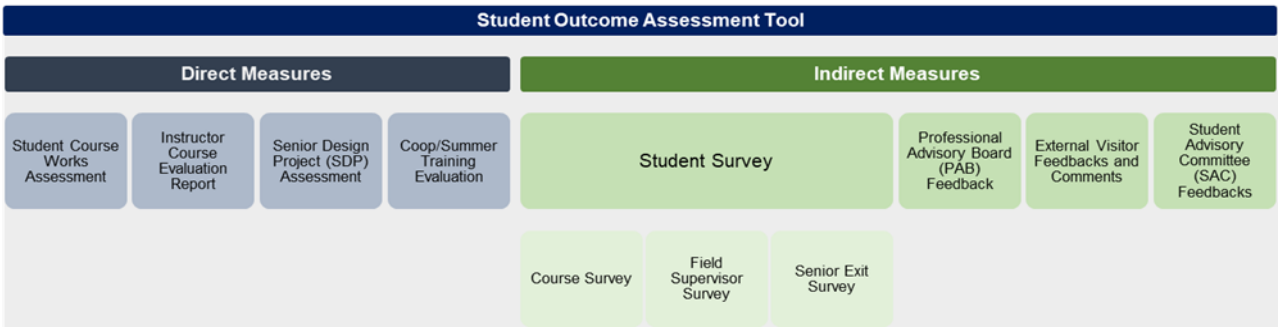

Fig. 1: Assessment and evaluation process adopted by EE program.

The integration of both direct and indirect assessment tools is crucial for achieving a comprehensive understanding of program effectiveness. Direct assessments yield tangible, observable evidence of students' skills and knowledge, whereas indirect assessments reflect students' perceptions and overall satisfaction with the program. These methods allow institutions to refine curricula, improve teaching methodologies, and enhance student support services, thereby better aligning with targeted learning outcomes and ensuring graduates are adequately prepared for their professional careers.

4. MODEL VALIDATION

In academic programs, especially in engineering education, evaluating student progress against established criteria is essential for ensuring quality and responsibility. Programs use Performance Indicators (PIs) as measurable, exact criteria to evaluate the effectiveness of Student Outcomes (SOs) or Program Learning Outcomes (PLOs) [42]. These PIs are carefully structured to provide clarity on the expected student performance in terms of both depth and content. Each PI is constructed with two essential elements: an action verb, which indicates the level or intensity of the skill to be demonstrated and a content referent, which clarifies the subject matter or context in which the student should apply this skill. For instance, an outcome might require a student to "demonstrate" analytical skills or to "differentiate" between key concepts, which creates a clear, observable standard by which performance can be assessed.

These PIs are integral to the design and development of the curriculum because they translate broader learning outcomes into concrete, actionable tasks. PIs offer a framework for data collection and performance assessment by delineating the actions or tasks expected of students. This level of detail is crucial for determining not only the skills and knowledge that students should acquire or values they should possess but also the methods by which they will demonstrate their understanding of the subject matter.

In the case of the QEC at Qassim University, PIs are particularly crucial. As the QEC works toward meeting international academic standards, specifically those set by ABET for accreditation, these indicators serve as vital tools for alignment. The QEC has established specific PIs related to the ABET-adopted SOs, which are outlined in Table 3, to ensure that program outcomes meet the rigorous standards required for accreditation. Subdividing each SO into specific PIs and linking courses with PIs enables the QEC to facilitate effective curriculum design while establishing a foundation for systematic improvement, thereby ensuring consistent and transparent achievement of the program's educational objectives.

This comprehensive method for identifying and using performance indicators enables the institution to discern areas of achievement and recognize chances for improvement. This alignment ensures that the program's objectives correspond with the capabilities necessary for graduates entering the workforce, so improving the quality of the educational experience and equipping students to address industry requirements with consistency and assurance.

5. SUGGESTED UNIFIED ASSESSMENT AND EVALUATION METHOD

To streamline the outcomes assessment process, both Student Outcomes (SOs) and Program Learning Outcomes (PLOs) in the engineering programs are systematically linked to the Performance Indicators (PIs) as outlined in Table 4. This integrated approach enables a more efficient evaluation of student achievement by preventing duplication of effort across multiple accreditation requirements, as it satisfies the criteria for both ABET and NCAAA accreditations. By using shared PIs, the assessment process can be standardized, reducing redundancy in data collection and analysis while upholding the unique criteria set by each accreditation body.

Table 3: Performance Indices (PIs) for the SOs (New ABET Criteria) for Electrical Engineering Program, at Qassim University's College of Engineering.

SO_1: ***An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics***		
Performance Indicators	PI_1.1	Recall knowledge of Basic sciences (math, physics, management, economy, etc.) and Basic Engineering sciences.
	PI_1.2	Identify the basic science concepts governing engineering problems
	PI_1.3	Mathematically formulate the engineering problems
	PI_1.4	Apply appropriate techniques in solving complex engineering problems considering assumptions
	PI_1.5	Evaluate problem solutions
	PI_1.6	Comprehensively identify research and inquiry methodologies
	PI_1.7	Conduct inquiries, investigations, and research into complex issues and problems
SO_2: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors		
Performance Indicators	PI_2.1	Identify design requirements and recognize constraints
	PI_2.2	Produce design alternatives.
	PI_2.3	Apply design approaches (methodologies)
	PI_2.4	Verify and evaluate the design of component/system/process against the needs and constraints.
SO_3: ***An ability to communicate effectively with a range of audiences***		
Performance Indicators	PI_3.1	Ability to communicate ideas and technical aspects in written technical reports using various means of written communication
	PI_3.2	Ability to give oral communications through presentation with a range of audiences.
SO_4: ***An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts***		
Performance Indicators	PI_4.1	Recognize ethical and professional aspects
	PI_4.2	Analyze and apply Ethical and professional dimensions in engineering practices

SO_5: ***An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives***		
Performance Indicators	PI_5.1	Demonstrates leadership skills such as planning tasks, assigning work to team members, and evaluating achievements.
	PI_5.2	Function effectively in teamwork in terms of participation in discussions, giving ideas, accepting criticism, and contributing to the tasks
SO_6: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions		
Performance Indicators	PI_6.1	Conduct experiments
	PI_6.2	Analyze and present data using statistical and graphical tools
	PI_6.3	Interpret the data and draw the conclusion
	PI_6.4	Develop experiment and test procedure(s).
SO_7: ***An ability to acquire and apply new knowledge as needed, using appropriate learning strategies***		
Performance Indicators	PI_7.1	Ability to seek needed information from different sources and apply it.
	PI_7.2	Ability to acquire new knowledge through pursuing postgraduate studies or professional training

Table 4: Linkage between adopted ABET Student Outcomes (SO), formulated Performance Indices (PIs) and NCAAA Program Learning Outcomes (PLOs) for Electrical Engineering Program, at Qassim University's College of Engineering.

ABET SOs	**SO_1**							**SO_2**				**SO_3**		**SO_4**		**SO_5**		**SO_6**				**SO_7**	
Performance Indicator	PI_1.1	PI_1.2	PI_1.3	PI_1.4	PI_1.5	PI_1.6	PI_1.7	PI_2.1	PI_2.2	PI_2.3	PI_2.4	PI_3.1	PI_3.2	PI_4.1	PI_4.2	PI_5.1	PI_5.2	PI_6.1	PI_6.2	PI_6.3	PI_6.4	PI_7.1	PI_7.2
NCAAA PLOs	K_1	K_2	S_1	S_2		K_3	S_5	S_3				S_4		V_1		V_3		S_6				V_2	

6. APPLICATION (IMPLEMENTATION) OF THE SUGGESTED METHOD

The selection of courses for an engineering program is a well-structured procedure that integrates academic rigor with the whole development of students. This approach involves pairing courses with Program Learning Outcomes (PLOs) and Program Educational Objectives (PEOs), which are fundamental components that define the program's short-term and long-term goals.

PEOs are visionary statements that encapsulate the aspirations of graduates a few years after they have completed the program. These goals delineate the responsibilities graduates are anticipated to assume in their professional endeavors, whether by achieving career excellence, addressing societal requirements, or progressing via professional development and leadership. They signify the enduring effects of the program, including objectives such as addressing intricate engineering problems, promoting innovation, and upholding ethical standards in a swiftly changing environment.

Conversely, PLOs are more detailed and immediate. They outline the requisite information, abilities, and attitudes that students are anticipated to attain upon graduation. These achievements may include a robust foundation in fundamental sciences and mathematics, practical expertise in design and experimentation, adeptness in communication, and a heightened understanding of ethical and professional obligations. PLOs function as the foundational elements that together facilitate the attainment of the overarching objectives specified in the PEOs.

Courses are carefully selected and structured to systematically develop these abilities, ensuring a unified and intentional learning experience. This alignment guarantees that students fulfill accreditation criteria while developing essential skills and attitudes for their career endeavors and significant societal contributions.

6.1. Mapping Learning Outcomes: Beyond Basic Alignment

The alignment of courses with learning outcomes is accomplished by a systematic mapping of Course Learning Outcomes (CLOs) to Student Outcomes (SOs) and Program Learning Outcomes (PLOs). This mapping is achieved using Performance Indicators (PIs), which measure and delineate the achievement of certain goals. Nonetheless, just mapping is inadequate. It is equally important to ascertain the depth and intensity of these connections within the curriculum.

The curriculum employs a systematic classification to delineate the degree of association between each course and the Program Learning Outcomes (PLOs) or Student Outcomes (SOs), therefore making these connections clear and actionable. These levels not only indicate the relative significance of PIs linked to a certain result in a course but also consider the course's placement within the program. For example, foundational courses might introduce concepts (I), while capstone projects allow students to demonstrate mastery (M). The curriculum employs a systematic classification to delineate the degree of link between each course and the Program Learning Outcomes (PLOs) or Student Outcomes (SOs) as shown in Table 5.

Table 5: Systematic categorization to define the level of correlation between each course and ABET SOs and NCAAA PLOs.

ABET SOs			**NCAAA PLOs**		
Correlation Level	**Description**	**Representation**	**Correlation Level**	**Description**	**Representation**
High	Strongly supports the SO	(H/■) /	Mastered	The course ensures mastery of the outcome	(I)
Medium	Moderately supports the SO	(M/▣)	Practiced	The outcome is further developed and applied	(P)
Low	Provides minimal support to the SO	(L/◘)	Introductory	The course introduces the outcome	(M)
No	Does not address the SO	(N/□)	Not Applicable	The outcome is not addressed in the course	(N)

6.2. A Gradual Journey Toward Mastery

This systematic method guarantees that students' learning is supported, enabling them to gradually develop skills. They progress from a fundamental comprehension in their formative years to the mastery of intricate ideas and abilities in advanced coursework. This progression reflects the development path of a professional engineer, guaranteeing that graduates are adequately equipped for technological challenges and social demands.

6.3. Assessment and Continuous Improvement

During the summative evaluation phase, these connections are essential. The program assesses the overall attainment of SOs and PLOs, especially in senior-level courses, using rubric systems, as detailed in Table 6. These rubrics measure not just the fulfillment of immediate course objectives but also the extent to which these objectives align with broader program outcomes.

The engineering program employs a rigorous and thoughtful methodology to guarantee that its curriculum is both academically robust and fundamentally oriented towards promoting professional and social contributions. The integration of SOs and PLOs at varying levels of complexity guarantees that students graduate as competent, ethical, and visionary engineers, ready to leave their mark on the world.

Table 6: Rubrics for summative assessment of learning outcomes using specified course.

Correlation Level	Representation	% Contribution to overall
High / Mastered	(H/■) / (M)	100%
Medium / Practiced	(M/▣) / (P)	75%
Low / Introductory	(L/◘) / (I)	50%
No / Not Applicable	(N/□) / (N)	0%

When selecting courses to assess specific outcomes, the following guidelines support a targeted and impactful assessment strategy:

- **Upper-Level Course Selection for Direct Outcomes Assessment:** Since SOs and PLOs represent the cumulative skills, knowledge, and competencies students should demonstrate by graduation, courses chosen for assessment should ideally be at the upper levels of the program. Therefore, courses with a linkage level of, 'Medium (M/■) /Practiced (P)' or 'High correlation (H/■), Mastered (M)' are particularly suited for assessing these outcomes, as they reflect a higher level of student proficiency and understanding.

- **Strategic Spacing of Courses for Outcome Evaluation:** To provide a robust and actionable evaluation of each outcome, the selected courses for assessing any given SO or PLO should be distributed across different levels or academic years. This spacing allows program committees to identify and address any deficiencies or areas for improvement within an outcome well before students reach the end of their program. In doing so, programs can adjust instruction, provide targeted support, and continuously improve learning outcomes based on interim assessments.

- **Reducing Faculty Workload by Selecting Courses Covering Multiple Outcomes:** To ensure a manageable workload for faculty, courses that are linked to multiple SOs or PLOs are prioritized for outcomes assessment. This approach allows faculty to collect data for multiple outcomes within a single course, facilitating a comprehensive yet streamlined assessment process.

- **Emphasis on Senior-Level and Capstone Courses:** Capstone experiences such as the Senior Design Project(s) and senior-level experiential learning, such as Summer/Cooperative Training, provide critical opportunities for assessing complex, integrative outcomes. These courses, typically offered in the final stages of the program, are particularly effective for outcomes assessment because they require students to demonstrate a holistic application of the skills and knowledge accumulated throughout the program. The project-based and practical nature of these courses allows for a more nuanced and realistic evaluation of students' readiness for professional practice, directly aligning with both ABET and NCAAA's emphasis on practical competency and application.

This structured and deliberate approach to course selection and outcome linkage supports a comprehensive and sustainable assessment framework. By aligning SOs and PLOs with specific, measurable PIs across the curriculum, the program ensures that its graduates meet both national and international standards, while also maintaining flexibility to adapt and improve as needed. Ultimately, this alignment not only satisfies accreditation requirements but also enhances the quality of student learning and readiness for the engineering profession. Samples of the mapping for the selected courses are given in Table 7.

Electrical Engineering programs incorporate this standardized assessment process to provide a systematic evaluation of student learning results. This commences with the association of course learning outcomes (CLOs) to carefully developed performance indicators (PIs). The PIs are then assessed using both direct and indirect approaches, and the findings are used to determine the achievement levels of ABET Student Outcomes (SOs) and NCAAA Program Learning Outcomes (PLOs). The correlation between PIs and outcomes is measured by a previously mentioned weighting technique in this section. An essential component of this approach is evaluating both the depth and breadth of achievement, which offers a comprehensive perspective on student performance. Depth is assessed by calculating the mean average (AM) of student grades, while breadth is measured by the percentage of students (PNS) attaining the threshold level of 70%. The research emphasizes that evaluating both aspects guarantees a comprehensive assessment, including overall class performance while pinpointing individual strengths or weaknesses within the cohort. Depth signifies an amount of accomplishment,

whilst breadth offers perspectives on the comprehensiveness of educational attainment. This methodology is elucidated using the sample course, GE211 “Introduction to Engineering Design”, via direct evaluation. Figure 2 depicts the mean PI evaluations (PNS and AM) across several assessment tools, including quizzes, assignments, projects, reports, presentations, midterm examinations, and the final examination.

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Table 7: Samples of course mapping to the SOs (High correlation (H/■), Medium(M/▣, Low correlation (L/◘) and No correlation (N/□)) and for PLOs mastered (M), Practiced (P), Introductory (I), Not applicable (N).

SOs	PIs	PLOs	GE 211			EE 330			EE 432			EE491			EE 492			ST 406		
			PI	SO	PLO	PI	SO	PLO	PI	SO	PLO	PI	SO	PLO	PI	SO	PLO	PI	SO	PLO
SO_1	PI_1.1	K_1			N			N			N	✓		M	✓		M	✓		M
	PI_1.2	K_2			N			N			N	✓		M	✓		M	✓		M
	PI_1.3	S_1	✓		M			N			N	✓		M	✓		M	✓		M
	PI_1.4	S_2		◘	N	✓	◘	M	✓	◘	M	✓	■	M	✓	■	M	✓	▣	P
	PI_1.5					✓			✓			✓			✓					
	PI_1.6	K_3	✓		M			N			N	✓		M	✓		M			N
	PI_1.7	S_5	✓		M			N			N	✓		M	✓		M			N
SO_2	PI_2.1	S_3	✓	▣	P	✓	■	M	✓	▣	P	✓	■	M	✓	■	M		□	N
	PI_2.2					✓						✓			✓					
	PI_2.3		✓			✓			✓			✓			✓					
	PI_2.4					✓						✓			✓					
SO_3	PI_3.1	S_4	✓	■	M		□	N		□	N	✓	■	M	✓	■	M	✓	■	M
	PI_3.2		✓									✓			✓			✓		
SO_4	PI_4.1	V_1	✓	▣	P		□	N		□	N	✓	■	M	✓	■	M	✓	■	M
	PI_4.2											✓			✓			✓		
SO_5	PI_5.1	V_3	✓	■	M		□	N		□	N	✓	■	M	✓	■	M	✓	■	M
	PI_5.2		✓									✓			✓			✓		
SO_6	PI_6.1	S_6		□	N	✓	■	M	✓	▣	P		□	N	✓	■	M	✓	◘	I
	PI_6.2					✓			✓						✓					
	PI_6.3					✓									✓					
	PI_6.4														✓					
SO_7	PI_7.1	V_2	✓	▣	P		□	N		□	N	✓	■	M	✓	■	M	✓	■	M
	PI_7.2											✓			✓			✓		

7. APPLICATION (IMPLEMENTATION) OF THE SUGGESTED METHOD

Figure 2 depicts the mean PI evaluations (PNS and AM) across several assessment tools, including quizzes, assignments, projects, reports, presentations, midterm examinations, and the final examination.

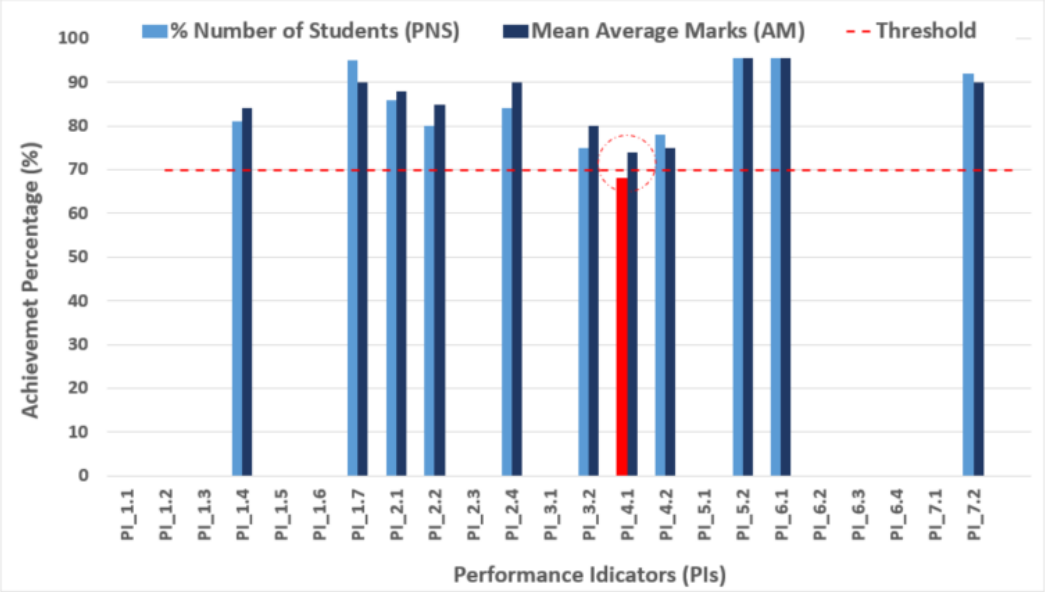

Fig. 2: Assessment of PIs for Course GE211– (Fall 2021/2022).

Furthermore, Table 5 delineates the achievement levels of ABET Student Outcomes (SOs) and NCAAA Program Learning Outcomes (PLOs) based on the assessed Performance Indicators (PIs), whereas Figures 3 and 4.

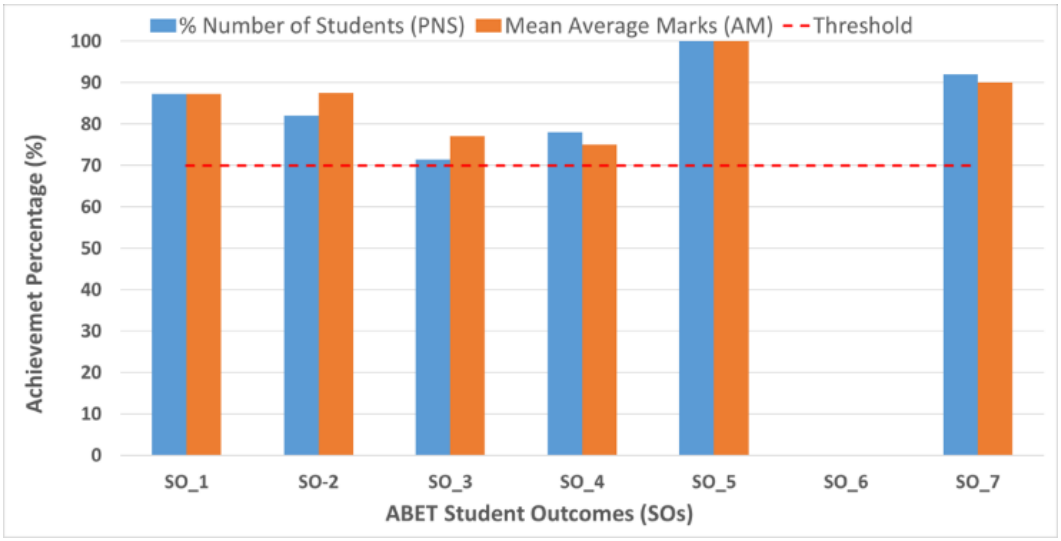

Fig. 3: Assessment of SOs based on the PIs and linkage level for Course GE211– (Fall 2021/2022).

As evidenced by Figures 3 and 4, relying solely on the overall evaluation results for Student Outcomes (SOs) and Program Learning Outcomes (PLOs) might lead to a misleading conclusion that all SOs and PLOs have achieved the required performance levels. This method does not adequately identify potential weaknesses at a more detailed level.

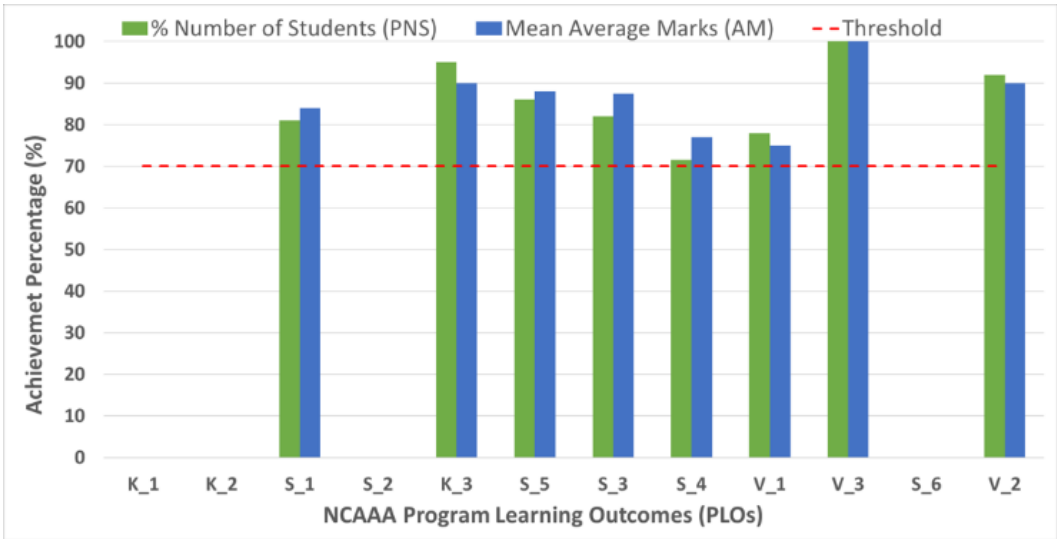

Fig. 4: Assessment of PLOs based on the PIs and linkage level for Course GE211– (Fall 2021/2022)

As can be seen in Figure 2, a more in-depth investigation demonstrates that the performance indicator (PI) assessment offers essential insights that would otherwise be not readily apparent. The PNS (% Number of Students) achieved level of PI_3.2 fails to meet the target threshold, despite the aggregated results for SOs and PLOs indicating sufficient achievement. This discrepancy highlights the necessity of examining outcomes at the PI level to pinpoint particular areas needing focus. Through comprehensive assessments at the PI level, quality assurance departments can accurately identify areas of weakness. Formative assessments can be utilized to identify underperforming PIs within particular courses of a cohort. This approach facilitates the planning of specific corrective measures to rectify deficiencies in future courses, thereby improving the overall achievement levels of SOs and PLOs. This systematic, iterative process enhances specific performance indicators and fosters continuous improvement in overall learning outcomes, ensuring alignment of evaluation and accreditation processes with high standards of quality assurance.

8. CONCLUSIONS

In this study, we present an integrated method for evaluating learning outcomes that aligns with both ABET and NCAAA accreditation frameworks. This method minimizes redundancy, reducing faculty workload and documentation while ensuring a streamlined, transparent, and effective assessment process.

Central to this approach is the design of performance indicators (PIs) that clearly define expected student performance in terms of depth (cognitive complexity) and breadth (content coverage). Course learning outcomes (CLOs) are systematically linked to PIs, which are evaluated using direct (e.g., exams, projects) and indirect (e.g., surveys) tools. This comprehensive methodology measures achievement levels both vertically (depth via Average Marks) and horizontally (breadth via the percentage of students meeting benchmarks).

This method has been successfully implemented in the College of Engineering at Qassim University. It has been shown to be effective in reducing the workload of faculty members by eradicating redundant assessment processes and minimizing documentation, thereby alleviating administrative burdens. It improves diagnostic capabilities by emphasizing discrete program indicator (PI)-level assessments, which facilitate the identification of vulnerable areas and the implementation of preemptive quality assurance measures to enhance student outcomes. Additionally, the approach is designed to facilitate continuous improvement by facilitating data-driven decision-making, which enables academic programs to iteratively refine learning outcomes and more effectively accord with accreditation standards. It provides a scalable, efficient solution for institutions that manage multiple accreditation requirements, thereby illustrating its potential as a model for optimizing

assessment and accreditation practices. Its successful implementation at Qassim University serves as a potential model for other institutions that are interested in optimizing their assessment processes.

AUTHOR CONTRIBUTIONS

Conceptualization, M.A.A. and R.A; methodology M.A.A. and M.A.; software, R.A.; validation, M.A.A. and M.A; formal analysis, M.A.A., R.A. and M.A; investigation, M.A.A. and R.A; resources, M.A.; data curation, M.A.A. and R.A; writing—review and editing, M.A.A., R.A. and M.A; visualization, R. A.; supervision, M.A.A.; project administration, M.A.; and funding acquisition, M.S.A. author have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable. Informed Consent Statement: Not applicable.

DATA AVAILABILITY STATEMENT

The supplementary data used in the work can be obtained from the corresponding author upon reasonable requests.

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Arabic Abstract

طريقة موحدة لتقويم مخرجات برامج بكالوريوس الهندسة صالحة لنظم الاعتماد الأكاديمي المختلفة

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تقدم هذه الدراسة بتقديم منهجية مقترحة لتوحيد أسلوب تقييم نواتج تعلم البرامج الأكاديمية، مع الحفاظ على الالتزام بمعايير هيئات الاعتماد المتعلقة بتلك النواتج، مثل الهيئة الدولية (ABET) والمركز الوطني للتقويم والاعتماد الأكاديمي (NCAAA) في المملكة العربية السعودية. إن تباين متطلبات ومصطلحات وعبارات نتائج التعلم بين هيئات الاعتماد المختلفة غالباً ما يزيد من عبء العمل ويضاعف من تعقيد عملية التقويم على أعضاء هيئة التدريس والموظفين، وللتغلب على هذه التحديات، يقترح البحث منهجية متكاملة توحّد عملية التقييم من خلال تفصيص نتائج التعلم العريضة إلى مؤشرات أداء (نتائج تعلم فرعية) محددة ومركزة وقابلة للقياس، والتي حينئذ يتم ربطها بسهولة بمجموعة نتائج التعلم المقترحة والمتوافقة مع نظام الاعتماد المطبق. وقد تم تطبيق هذا النهج في كلية الهندسة بجامعة القصيم، والتي تلتزم بمعايير كل من ABET والمركز الوطني للتقويم والاعتماد الأكاديمي. وقد أظهرت النتائج فعالية هذا النهج، حيث أدى إلى تقليل كبير في الجهد والوقت اللازمين للتقييم، بالإضافة إلى تحسين دقة تحديد نقاط الضعف في نتائج التعلم، وبذلك، يُعد هذا النظام المتكامل أداة فعالة للمؤسسات التعليمية الساعية إلى تعزيز جودة تعليمها، مع الوفاء بمعايير هيئات الاعتماد المختلفة. وتدعم هذه الدراسة تبني منهجية التقييم الموحدة على نطاق أوسع كوسيلة لتحسين جودة التعليم بشكل منهجي وضمان الالتزام بمعايير الاعتماد في ظل بيئة الاعتماد المعقدة والمتغيرة باستمرار في التعليم العالي.

كلمات مفتاحية: نواتج التعلم، الاعتماد، ضمان الجودة، معايير الاعتماد، ABET، المركز الوطني للتقويم والاعتماد الأكاديمي، أعباء منسوبي الكلية، عملية التقدير، جودة التعليم.