RUBRICS *for* GRADUATE ATTRIBUTES, COMPLEX ENGINEERING PROBLEMS AND ACTIVITIES

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COLLEGE OF ENGINEERING
UNIVERSITI TEKNOLOGI MARA

The Rubrics for Graduate Attributes, Complex Engineering Problems and Activities are intended as a pedagogical assessment tool used by College of Engineering, Universiti Teknologi MARA instructors for individual courses, as well as at the programme level.

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1.0 INTRODUCTION

1.1 Introduction

Learning takes place in students' minds, where it is invisible to others. Students' understanding of the subject or courses must be assessed through their performance, which depends very much on the assessment methods given to the students. Assessment methods, on the other hand, rely on the learning outcome(s) of the course. In other words, assessment demonstrates students' achievement of the specific learning outcome or objective set in the course outline. For an assessment that involves open answers or responses from students, such as report writing, design work, presentation, drawing, ideas, discussion, interviews, feedback and a few more, a rubric is needed to ensure fair distribution of marks. The following sections will briefly present the objective of this document, followed by the relevant information to help lecturers and instructors in designing rubrics for their assessment.

1.1.1 Objectives

This document is a general guideline for preparing pedagogical assessment tools used by instructors involved in teaching and learning (T&L) activities at the College of Engineering, UiTM. This guideline covers Rubrics for Graduate Attributes, for Complex Engineering Problems (CEPs) and Activities (CEAs) for engineering degree programs.

The rubrics in this document were developed to fulfil the following elements.

(i) The foci and indicators used adequately communicate the knowledge, skills, attitudes, values and behaviours as required by the Graduate Attributes, as agreed by the stakeholders of the programmes offered by the College of Engineering, UiTM;
(ii) The competency level for each indicator used defines proficiency, as agreed by the stakeholders of the programmes offered by the College of Engineering, UiTM; and
(iii) The key verbs used to describe the rubrics indicators are consistent and measurable, as agreed by the stakeholders of the programmes offered by the College of Engineering, UiTM.

1.1.2 Rubrics

A rubric is an assessment tool that facilitates the process of evaluation and reporting of student achievement by educators [1]. It acts as a descriptive tool to promote understanding and direct future instruction and learning. In addition, it provides transparent criteria for assessment for all stakeholders (faculty, instructors, students, alumni and industries). The College of Engineering, UiTM Graduate Attribute Rubrics can facilitate a common understanding and language for engineering programme stakeholders (lecturers, students, alumni, external examiners and industries) addressing the 12 POs graduate attributes. The rubrics can also be used by the students for performance self-monitoring and peer evaluation assessments.

Programme Outcomes (PO) describe what students are expected to know and be able to perform or attain upon graduation. These relate to the skills, knowledge, and behaviour students acquire through the programme. Students of an engineering programme are expected to attain the following POs, based on the EAC Standard 2020 requirements [2] and adopting some of the new requirements by the Graduate Attributes & Professional Competencies 2021 (GAPC2021) [3].

The EAC Standard 2020 has prescribed 12 programme outcomes or graduate attributes with complex engineering problems **(CEP)**, complex engineering activities **(CEA)**, and knowledge profiles **(WK)** to be incorporated in all engineering programmes, as shown in Table 1, 2, 3 and 4.

Table 1. List of 12 EAC Graduate Attributes or Programme Outcomes (EAC Standard, 2020) mapped to the Graduate Attributes and Professional Competency (GAPC, 2021).

No.	Programme Outcome (PO) Statement (EAC Standard 2020)		Graduate Attributes (WA) & Professional Competencies (GAPC2021)	
PO1	Engineering Knowledge	Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems	WA1: Engineering Knowledge: Breadth, depth and type of knowledge, both theoretical and practical	Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialization as specified in WK1 to WK4 respectively to develop solutions to complex engineering problems
PO2	Problem Analysis	Identify, formulate, conduct research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4)	WA2: Problem Analysis Complexity of analysis	Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences with holistic considerations for sustainable development* (WK1 to WK4)
PO3	Design/ Development of Solutions	Design solutions for complex engineering problems and design	WA3: Design/ development of solutions: Breadth and uniqueness of	Design creative solutions for complex engineering problems and design systems, components or processes to

		systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5)	engineering problems i.e., the extent to which problems are original and to which solutions have not previously been identified or codified	meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required (WK5)
PO4	Investigation	Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions	WA4: Investigation: Breadth and depth of investigation and experimentation	Conduct investigations of complex engineering problems using research methods including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions (WK8)
PO5	Modern Tool Usage	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6)	WA5: Tool Usage: Level of understanding of the appropriateness of technologies and tools	Create, select and apply, and recognize limitations of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems (WK2 and WK6)
PO6	The Engineer and Society	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7)	WA6: The Engineer and the World: Level of knowledge and responsibility for sustainable development	When solving complex engineering problems, analyze and evaluate sustainable development impacts* to: society, the economy, sustainability, health and safety, legal frameworks, and the environment (WK1, WK5, and WK7)
PO7	Environment and Sustainability	Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts (WK7)		
PO8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7)	WA7: Ethics: Understanding and level of practice	Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9)
PO9	Individual and Team Work	Function effectively as an individual, and	WA8: Individual and Collaborative	Function effectively as an individual, and as a member or

		as a member or leader in diverse teams and in multidisciplinary settings	Teamwork: Role in and diversity of team	leader in diverse and inclusive teams and in multi-disciplinary, face-to-face, remote and distributed settings (WK9)
PO10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	WA9: Communication: Level of communication according to type of activities performed	Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences.
PO11	Project Management and Finance	Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments	WA10: Project Management and Finance: Level of management required for differing types of activity	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO12	Life Long Learning	Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	WA11 Lifelong learning: Duration and manner	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change (WK8)
*Represented by the 17 UN Sustainable Development Goals (UN-SDG)				

Table 2. Range of Complex Problem Solving (CPS) and Complex Engineering Problem (CEP) Attributes based on the EAC Standard (2020) and Graduate Attributes (WA) & Professional Competencies (GAPC2021)

No.	Attribute	EAC Standard (2020)	Graduate Attributes (WA) & Professional Competencies (GAPC2021)
		Complex problems have characteristic WP1 and some or all of WP2 to WP7:	**Complex problems** have characteristic WP1 and some or all of WP2 to WP7
WP1	Depth of Knowledge Required	Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamental-based, first principles analytical approach.	Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamental-based, first principles analytical approach
WP2	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	Involve wide-ranging and/or conflicting technical, non-technical issues (such as ethical, sustainability, legal, political, economic, societal) and consideration of future requirements
WP3	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	Have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate suitable models
WP4	Familiarity of issues	Involve infrequently encountered issues.	Involve infrequently encountered issues or novel problems
WP5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	Address problems not encompassed by standards and codes of practice for professional engineering
WP6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	Involve collaboration across engineering disciplines, other fields, and/or diverse groups of stakeholders with widely varying needs
WP7	Interdependence	Are high level problems including many component parts or sub-problems.	Address high level problems with many components or sub-problems that may require a systems approach

Table 3. Range of Complex Engineering Activities (CEA) Attributes (EAC Standard, 2020) and Graduate Attributes (WA) & Professional Competencies (GAPC2021)

No.	Attribute	EAC Standard (2020)	Graduate Attributes (WA) & Professional Competencies (GAPC2021)
		Complex activities mean (engineering) activities or projects that have some or all of the following characteristics:	**Complex activities** mean (engineering) activities or projects that have some or all of the following characteristics:
EA1	Range of resources	Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies).	Involve the use of diverse resources including people, data and information, natural, financial and physical resources and appropriate technologies including analytical and/or design software
EA2	Level of interactions	Require resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues.	Require optimal resolution of interactions between wide-ranging and/or conflicting technical, nontechnical, and engineering issues.
EA3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	Involve creative use of engineering principles, innovative solutions for a conscious purpose, and research-based knowledge.
EA4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
EA5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	Can extend beyond previous experiences by applying principles-based approaches

Table 4. List of Knowledge Profiles (WK) (EAC Standard, 2020) and Graduate Attributes & Professional Competencies (2021)

No.	Knowledge Profile (EAC Standard 2020)	Graduate Attributes (WA) & Professional Competencies (GAPC2021)
WK1	A systematic, theory-based understanding of the **natural sciences** applicable to the discipline.	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline.	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge that supports **engineering design** in a practice area.	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area
WK6	Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline.	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	**Comprehension of** the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability.	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development*
WK8	Engagement with selected knowledge in the **research literature** of the discipline.	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	-	Ethics, inclusive behaviour and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes
*Represented by the 17 UN Sustainable Development Goals (UN-SDG)		

1.2 Bloom's taxonomy and domains

Bloom's Taxonomy is a classification that defines different levels of learning and skills that need to be imparted in teaching and learning. College of Engineering, UiTM, employs Bloom's Taxonomy to improve engineering curriculum, assessments, and teaching methods. Originally introduced in 1956, Bloom's Taxonomy was a concept created by Mr. Benjamin Bloom along with Mr. Edward Furst, Mr. Max Englehart, Mr. David Krathwohl and Mr. Walter Hill. The effort is to dissect and classify the varied domains of human learning. It comprises three learning domains:

- **Cognitive**: mental skills (knowing)
- **Affective**: growth in feelings or emotional areas (attitude or self, feelings, or heart)
- **Psychomotor**: manual or physical skills (skills, doing, or kinesthetics, tactile, haptic or hand/body)

Each of the domains is assigned to different levels of learning. It is important to note that each taxonomy domain's different levels of thinking are hierarchical. It includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills.

The minimum taxonomy requirement for diploma, undergraduate, masters, and PhD students would depend on the specific program of study and the level of proficiency required in different domains at each level of education. However, in general, cognitive, psychomotor and affective learning are typically included as a component of all educational programs. A typical minimum expectation of the taxonomies for engineering programmes is shown in Table 5 as follows. Each of the domains is assigned to different levels of learning. It is important to note that the different levels of thinking defined within each domain of the taxonomy are hierarchical. It includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. Nonetheless, the setting of minimum level of taxonomy displayed in Table 5 should be carried out at programme level rather than at individual course level.

Table 5. Typical minimum expectation of taxonomy domain for engineering programmes, based on interpretation from description of 11 MQF Learning Outcomes, presented in Appendix 2 of the MQF Framework, 2nd Edition.

Programme level	Types of taxonomy		
	Cognitive	Psychomotor	Affective
Diploma	C3	P4	A3
Undergraduate	C4	P4	A3
Master	C5	P5	A4
PhD	C6	P6	A5

This table should be tallied to the taxonomy's percentage distribution used in AIMS. The minimum expectations of the taxonomies used in Table 5 should be within the range of 60 – 70%, depending on the year of study. The remaining percentage should be distributed to other ranges of taxonomies. For example, the cognitive domain of C1 - C3 could have 10 – 20 % and C5 - C6 could have the range of 10 – 30 %. However, the distribution used for CEP and CEA is a subset of the abovementioned allocation.

The cognitive domain refers to learning that involves knowledge acquisition, comprehension, application, analysis, synthesis, and evaluation. The cognitive domain has six levels of thinking, ranging from the simplest to the most complex (see **Figure 1**). The additional verbs that can be used to explain further the six levels of thinking for cognitive taxonomy can be referred to in Table 6, which were adopted from the Bloom Taxonomy Indicator (Version 0332).

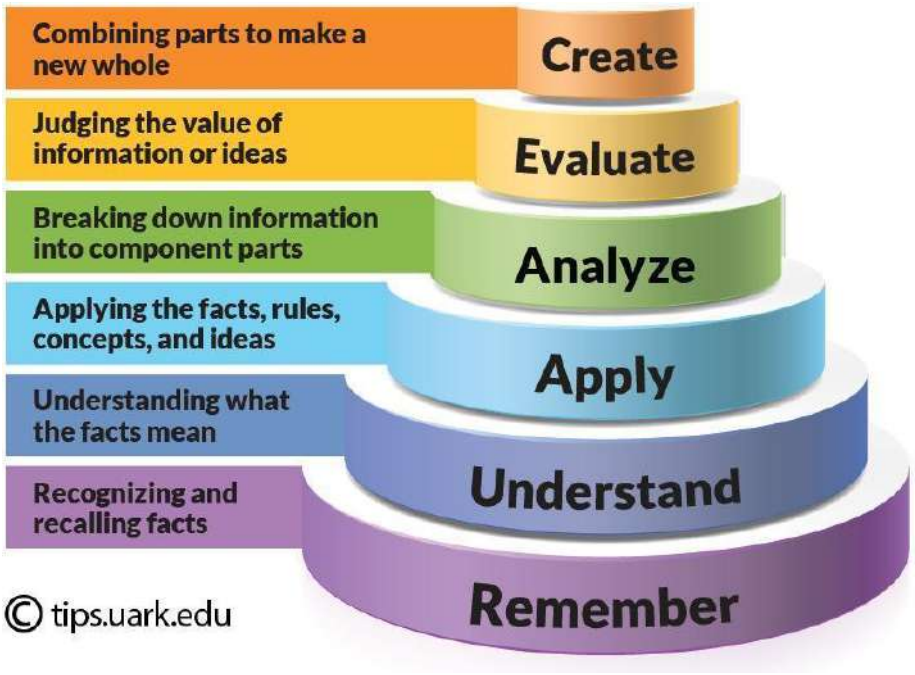

Figure 1. The Six Levels of Thinking in Bloom's Taxonomy (Anderson & Krathwohl (2001))

Table 6. Revised Bloom's Taxonomy – Cognitive Domain Key Verbs (Anderson & Krathwohl (2001)

Remembering	Understanding	Applying	Analysing	Evaluating	Creating
• Cite • Define • Describe • Extract • Find • Identify • Know • Label • List • Locate • Match • Measure	• Account • Alter • Change • Clarify • Classify • Compare • Comprehend • Contrast • Convert • Defend • Depict • Describe	• Apply • Assess • Build • Change • Choose • Classify • Compute • Construct • Demonstrate • Direct • Discover • Dramatise	• Analyse • Ascertain • Associate • Attribute • Break down • Calculate • Categorise • Classify • Contrast • Criticise • Debate • Designate	• Appraise • Assess • Choose • Compare • Collect • Conceive • Conclude • Consider • Contrast • Criticise • Critique • Decide	• Account • Alter • Argue • Arrange • Assemble • Begin • Categorise • Combine • Compile • Compose • Conceive • Construct

• Memorise • Name • Organise • Outline • Present • Pronounce • Quote • Recall • Recite • Recognise • Record • Recount • Relate • Reproduce • Select • State • Tell • Underline • Write	• Discover • Discuss • Distinguish • Estimate • Exemplify • Explain • Express • Extend • Find • Formulate • Generalise • Give • Give examples • Illustrate • Indicate • Infer • Interpret • Justify • Locate • Manage • Match • Paraphrase • Perform • Predict • Present • Recognise • Relate • Rephrase • Report • Represent • Restate • Review • Reword • Rewrite • Summarise • Transform • Translate • Vary	• Employ • Evidence • Illustrate • Interpret • Make • Manage • Manifest • Manipulate • Modify • Operate • Paint • Practice • Predict • Prepare • Present • Produce • Schedule • Show • Sketch • Solve • Use • Utilise • Verify	• Determine • Diagnose • Diagram • Differentiate • Discriminate • Dissect • Distinguish • Distinguish between • Divide • Elucidate • Examine • Experiment • Find • Identify • Illustrate • Illustrate how • Infer • Inquire • Inspect • Investigate • Justify • Probe • Question • Recognise • Reduce • Relate • Resolve • Select • Separate • Subdivide • Survey	• Deduce • Defend • Describe • Determine • Discriminate • Estimate • Evaluate • Explain • Interpret • Judge • Justify • Measure • Question • Rate • Recommend • Revise • Score • Summarise • Support • Value • Weigh	• Create • Derive • Design • Develop • Devise • Elaborate • Engender • Enlarge • Expand • Explain • Extend • Formulate • Generalise • Generate • Hypothesis • Image • Initiate • Integrate • Invent • Invert • Manage • Modify • Order • Organise • Originate • Pattern • Plan • Pose • Predict • Prepare • Present • Produce • Propose • Rearrange • Reconstruct • Relate • Reorganise • Report • Revise • Rewrite • Role-play • Summarise • Theorise • Write

In the psychomotor domain, the seven major categories are listed from the simplest behaviour to the most complex: Perception, Set, Guided Response, Mechanism, Complex Overt Response, Adaptation and Origination as shown in Figure 2. This domain involves the physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution. A list of verbs for the psychomotor domain can be found in Table 7. The verbs are adopted from Bloom Taxonomy Indicator (Version 0332).

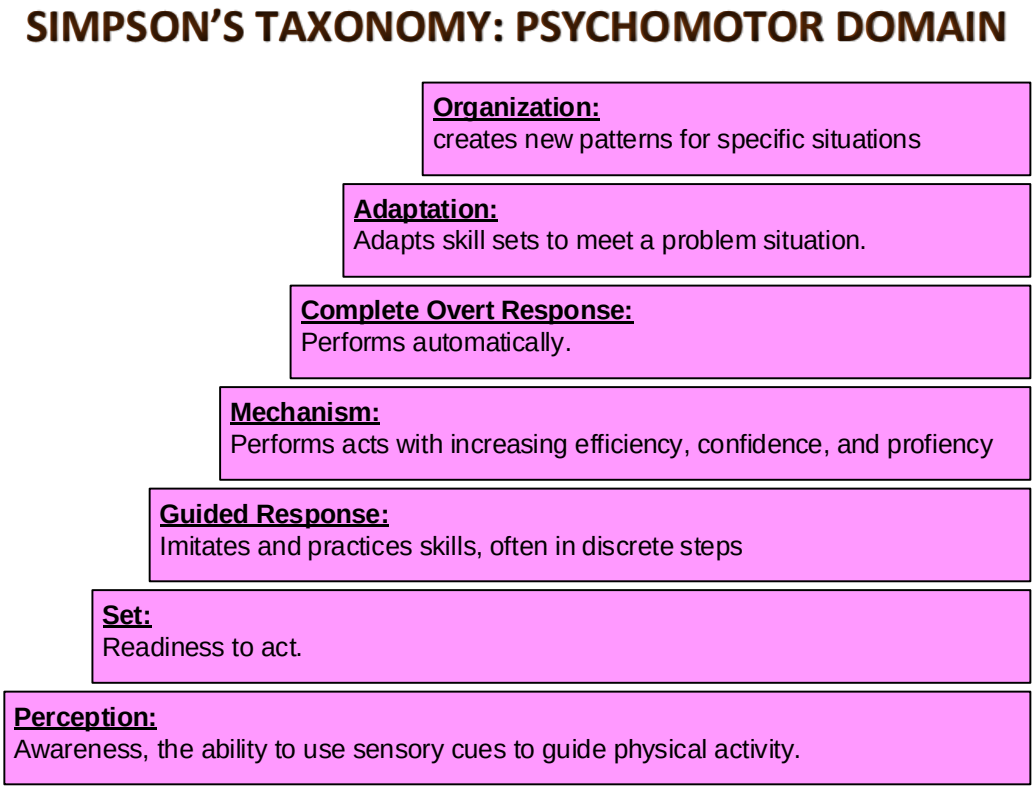

Figure 2. Simpson's Model in Bloom's Taxonomy: Psychomotor Domain
(source: Simpson E.J, 1972)

Table 7. Psychomotor Key Verbs **(Simpson E.J, 1972)**

Perception	Set	Guided Response	Mechanism	Complex Overt Response	Adaptation	Origination
• Choose • Describe • Detect • Differentiate • Distinguish • Identify • Isolate • Relate • Select	• Begin • Display • Explain • Move • Proceed • React • Respond • Show • State • Volunteer	• Assemble • Build • Calibrate • Construct • Copy • Dismantle • Display • Dissect • Fasten • Fix • Follow • Grind • Heat • Manipulate • Measure • Mend • Mix • Perform • React • Reproduce • Respond • Trace	• Assemble • Build • Calibrate • Construct • Dismantle • Display • Dissect • Fasten • Fix • Grind • Heat • Manipulate • Measure • Mend • Mix • Organise • Perform • Sketch	• Assemble • Build • Calibrate • Construct • Demonstrate • Dismantle • Display • Dissect • Fasten • Fix • Grind • Heat • Manipulate • Measure • Mend • Mix • Organise • Sketch	• Adapt • Alter • Change • Rearrange • Reorganise • Revise • Vary	• Arrange • Build • Combine • Compose • Construct • Create • Design • Initiate • Make • Originate

The affective domain (Krathwohl, Bloom, Masia, 1973) includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasm, motivations, and attitudes. The five major categories are listed from the simplest behaviour to the most complex: Receiving, Responding, Valuing, Organization, and Internalizing Values. Figure 3 shows the five categories of the affective domain, whilst **Table 8** shows the list of verbs that can be used to correspond to the categories.

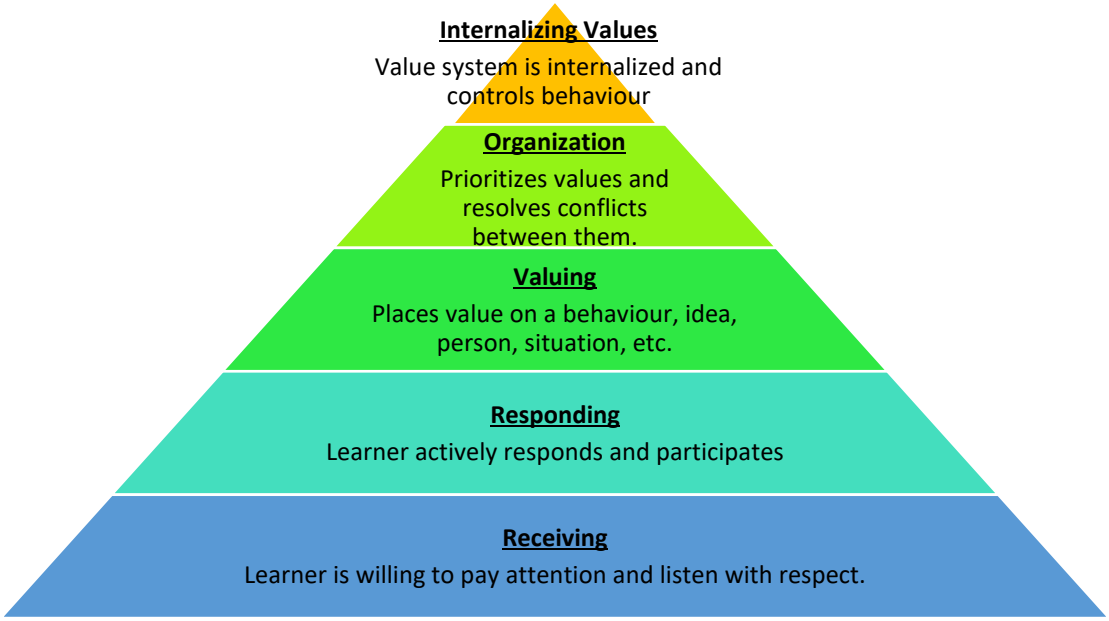

Figure 3. Krathwohl's Affective Domain

Table 8. Affective Domain Key Verbs **(Bloom et. al (1964))**

Receiving	Responding	Valuing	Organization	Internalizing values
• Ask • Choose • Describe • Erect • Follow • Give • Hold • Identify • Locate • Name • Point to • Reply • Select • Sit • Use	• Acclaim • Aid • Answer • Applaud • Approve • Assist • Comply • Comply with • Conform • Discuss • Form • Greet • Help • Label • Perform • Practice • Present • Read • Recite • Report • Select • Tell • Volunteer • Write	• Accept • Assist • Attend • Complete • Debate • Demonstrate • Deny • Differentiate • Explain • Follow • Form • Increase • Initiate • Invite • Join • Justify • Listen • Propose • Protest • Read • Relinquish • Report • Select • Share • Study • Work	• Accommodate • Adhere • Alter • Arrange • Balance • Combine • Compare • Complete • Defend • Explain • Formulate • Generalise • Identify • Integrate • Modify • Order • Organise • Prepare • Relate • Synthesise	• Act • Discriminate • Display • Influence • Interpret • Listen • Maintain objectivity • Modify • Perform • Practice • Propose • Qualifies • Question • Respect • Revise • Serve • Solve • Use evidence • Verify

2.0 RUBRICS FOR GRADUATE ATTRIBUTES

2.1 Introduction

The Engineering Accreditation Council (EAC) of BEM has specified 12 Programme Outcomes or Graduate Attributes specified by the EAC Standard 2020 for accrediting engineering programs (**Table 1**). The EAC Standard 2020 and the GAPC 2021 define what graduates are expected to know, be able to accomplish and how they should conduct themselves as professional engineers, which, in turn, relates to the skills, knowledge, and behaviour students learn through the programme.

The program outcomes specified by the EAC Standard 2020 can be categorized into three broad categories: knowledge, responsibilities (engineering practices and ethics), and skills or individual attributes as follows:

- Knowledge: Engineering Knowledge, experimentation and data analysis, problem analysis, contemporary issues, design, investigation, global awareness & the use of modern engineering tools.
- Responsibilities (Engineering Practices and Ethics): Design/Development of Solutions, Professionalism, Lifelong Learning, Project Management:
- Skills or Individual Attributes: Problem Analysis, Teamwork & Communication

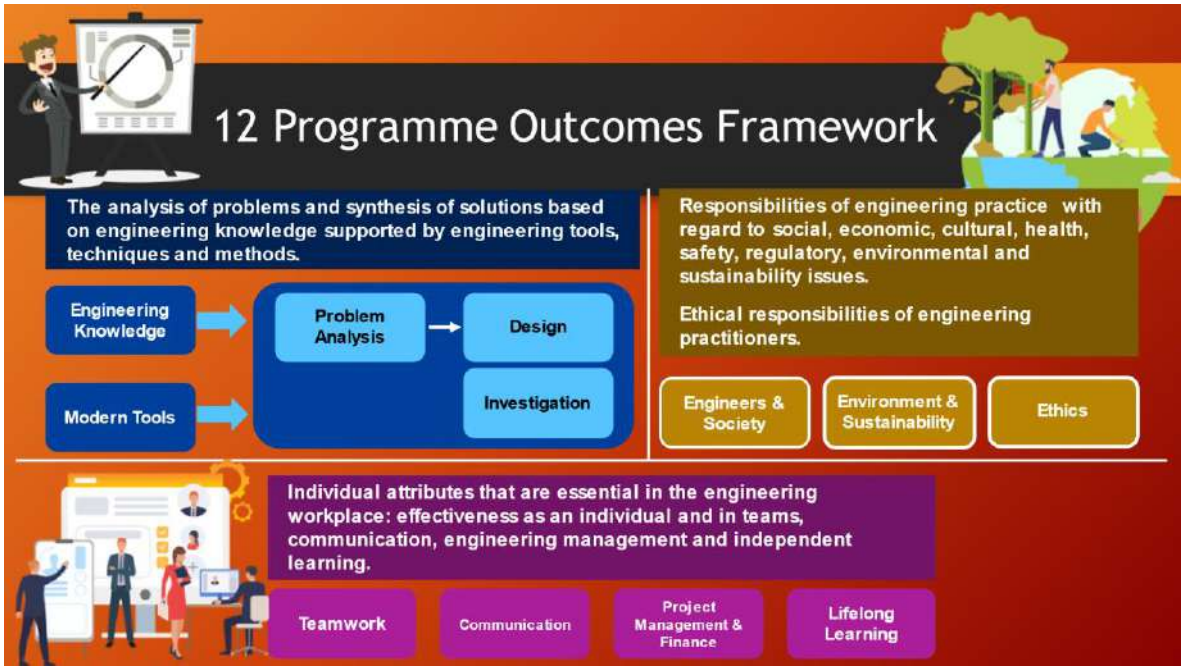

Figure 4. 12 Graduate Attributes consist of Knowledge, Skills and Responsibility

Upon graduation, the graduate engineer should have adequate knowledge in the related engineering field (WK1-WK4) to analyse and solve problems by synthesising the solutions using suitable tools and techniques (WK6). In designing and developing the solutions (WK5), the graduate engineer should investigate and be responsible regarding social, economic, cultural, health, safety, law and regulations, environment and sustainability (WK7), and demonstrates ethical and behaviour in their engineering practice (WK9). A good engineer also should have strong attributes essential in the engineering workplace to enable them to communicate effectively, work collaboratively in a team (WK9), use project management and finance, and be motivated to advance their knowledge through life-long learning (WK8).

Correctly assessing and measuring the programme outcome is very important in ensuring the performance of each graduate attribute. In general, each course will have course outcomes which serve as a promise or expectation at the end of the course. The course outcome will then be mapped to the programme outcome to identify the graduate attributes to be measured.

The performance criteria matrix or rubrics is a grading guide for lecturers, usually handed out before the assignment begins, as an effective assessment tool. It is an authentic assessment tool designed to simulate real-life activities where students solve real-life problems and make decisions. Rubrics are widely used to ensure consistent marking of open-type assessments. Through proper rubrics, grades or marking can be standardised and indirectly guide students in focusing on the needs of the questions. Following sections present the proposed rubrics for the 12 EAC's programme outcomes.

2.2 Proposed Rubrics for Programme Outcomes

This section proposes rubrics for programme outcomes PO1 to PO12 according to graduate attributes stated in the EAC PO statements.

Rubrics define and describe the progression towards meeting important components of work being completed, critiqued or assessed. Each category contains a gradation of levels of completion or competence with a score assigned to each level. It describes performance criteria that need to be met to attain the score at each level of competence. Figure 5 depicts the framework of the rubrics based on five (5) performance levels, namely Level 1 (Needs Work), Level 2 (Developing), Level 3 (Satisfactory), Level 4 (Competent) and Level 5 (Excellent).

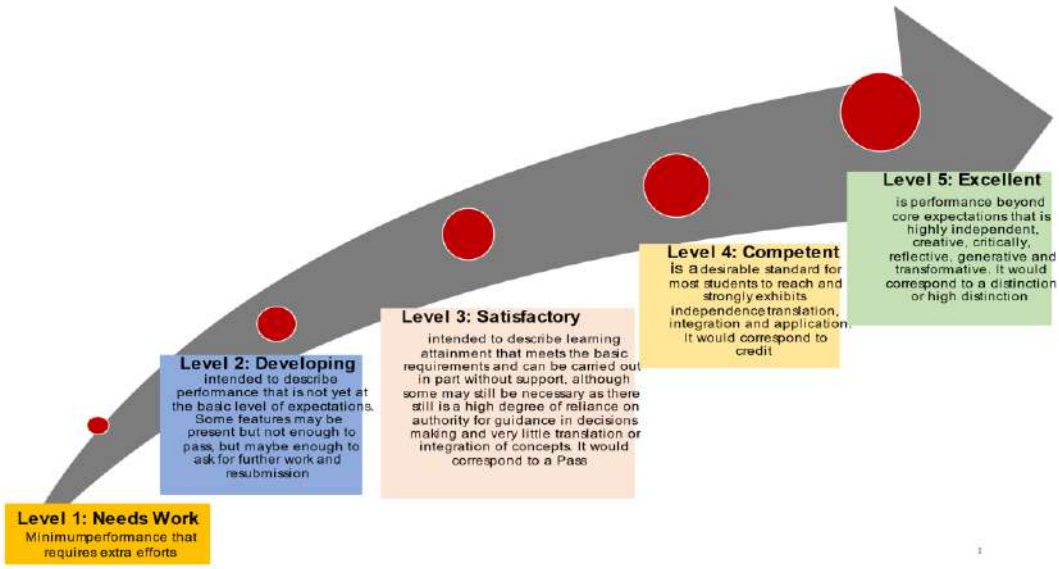

Figure 5. Framework of The Rubrics Consists of 5 Levels of Competency

Level 1 describes a minimum performance that requires much-needed work to improve. Level 2 describes performance that is not yet at the basic level of expectations. Some features may be present but not enough to pass, but maybe enough to ask for further work and resubmission. Level 3 describes learning attainment that meets the basic requirements (for the undergraduate programme) and can be carried out in part without support. However, some may still be necessary as there is a high degree of reliance on authority for guidance in decisions making and very little translation or integration of concepts. It would correspond to a Pass. Level 4 Describes a desirable standard for most students to reach and strongly exhibits independence, translation, integration and application. It would correspond to credit. Finally, Level 5 describes a performance beyond core expectations that is highly independent, creative, critical, reflective, generative and transformative. It would correspond to an excellent or distinction or high distinction.

The presented rubrics serve as a guideline for the coordinator and lecturer in designing their rubric. Each rubric is designed for the cognitive, psychomotor and affective domains. **Table 9** shows a proposed template for rubrics consisting of five levels of students' performance or achievement starting from Level 1 where extra work is needed to Level 5, which is Excellent. The statements in each level are based on the domain used and the level of the column. The Domain column, on the other hand, guides the user on the suitable verbs according to the cognitive, psychomotor and affective domains. The user can select which verb is suitable based on the Course outcome

Table 9. Rubrics Template for Five Levels of Students' Performance

Indicator (Domain)	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Domain with suggested verbs for different bloom levels					

Typically, the expectation for undergraduate students is to fulfil a satisfactory level, and hence the rubrics statements need to be aligned to suitable grades and mark bands. **Table 10** shows the corresponding mappings of competency levels, grades and mark bands used by UiTM.

Table 10. Mappings of competency level, grades and marks band for UiTM programmes

Level of competency	1 Needs work	2 Developing	3 Satisfactory	4 Competent	5 Excellent
Grade	F, E	D, D+, C-	C, C+	B-, B, B+	A-, A, A+
Mark band	0 – 39.9	40.0 – 49.9	50.0 – 59.9	60.0 – 74.9	75.0 – 100.0

The examples of rubrics shown in **Table 11** are based on the PO vs taxonomy mapping as practised by some/all the Schools of KPK. Nevertheless, these rubrics should be viewed as a starting point rather than a definitive list, as there may be other relevant criteria that need to be suited to the course requirement.

Table 11. Recommended mapping of PO vs taxonomy as used by the Schools of KPK

	Programme outcome											
	1	2	3	4	5	6	7	8	9	10	11	12
Cognitive	√	√	√	√	√	√	√				√	√
Psychomotor				√	√							
Affective						√	√	√	√	√	√	√

Examples of the rubrics created for each Programme Outcome are provided below. The types of taxonomy domains shown for the Programme Outcomes correspond to the taxonomy mapping shown in Table 11.

Table A1. Example of rubrics addressing cognitive taxonomy domain for Engineering Knowledge Programme Outcomes (PO1)

PO1 Engineering Knowledge - Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialisation as specified in WK1 to WK4, respectively to the solution of complex engineering problems					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Describe the scientific knowledge and mathematical analysis in engineering **(C2)**	Minimum description of scientific knowledge and mathematical analysis in engineering	Describe some scientific knowledge and mathematical analysis in engineering.	Describe satisfactorily scientific knowledge and mathematical analysis in engineering.	Describe good scientific knowledge and mathematical analysis in engineering.	Describe extensively scientific knowledge and mathematical analysis in engineering.
Apply essential assumptions and limitations in engineering problems **(C3)**	Minimum application of essential assumptions and limitations in engineering problems	Apply some essential assumptions and limitations in engineering problems	Satisfactorily apply essential assumptions and limitations in engineering problems	Apply good essential assumptions and limitations in engineering problems	Apply extensively essential assumptions and limitations in engineering problems
Identify and apply theory and application in engineering problems **(C4)**	Minimum identification of theory and application in engineering problems	Identify some theories and applications in engineering problems	Satisfactorily Identify theories and applications in engineering problems.	Identify good theories and applications in engineering problems.	Identify comprehensive theories and applications in engineering problems.
Evaluate the similarities and differences between the concepts, theories, methods or tools in solving engineering problems **(C5)**	Minimum identification of the similarities and differences between the concepts, theories, methods or tools in solving engineering problems	Identify and evaluate some similarities and differences between the concepts, theories, methods, or tools in solving engineering problems.	Satisfactorily identify and evaluate the similarities and differences between the concepts, theories, methods or tools in solving engineering problems.	Good evaluation of the similarities and differences between the concepts, theories, methods or tools in solving engineering problems	Comprehensively evaluate the similarities and differences between the concepts, theories, methods or tools in solving engineering problems.
Construct mathematical models to solve engineering problems **(C6)**	Minimum construction of mathematical models to solve engineering problems	Construct some mathematical models to solve engineering problems	Construct satisfactory mathematical models to solve engineering problems	Construct good mathematical models to solve engineering problems	Construct comprehensive mathematical models to solve engineering problems
Expand scientific and mathematical knowledge in engineering fundamentals and engineering specialization (**C6)**	Minimum expansion of scientific and mathematical knowledge in engineering fundamentals and engineering specialization	Expand some scientific and mathematical knowledge in engineering fundamentals and engineering specialization.	Expand satisfactory scientific and mathematical knowledge in engineering fundamentals and engineering specialization.	Expand good scientific and mathematical knowledge in engineering fundamentals and engineering specialization.	Expand comprehensive scientific and mathematical knowledge in engineering fundamentals and engineering specialization.

Table A2. Example of rubrics addressing cognitive taxonomy domain for Problem Analysis Programme Outcomes for (PO2)

PO2 Problem Analysis - Identify, formulate, conduct research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4)					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Identify and/or articulate engineering problems in a larger context **(C2)**	Minimum identification and/or articulation of engineering problems in a larger context	Limited ability to identify and/or articulate engineering problems in a larger context	Satisfactorily identify and/or articulate engineering problems in a larger context.	Completely identify and/or articulate engineering problems in a larger context.	Comprehensively identify and/or articulate engineering problems in a larger context.
Indicate research literature to solve engineering problems **(C2)**	Minimum performance of research literature to solve engineering problems	Limited ability to perform research literature to solve engineering problems	Satisfactorily perform research literature to solve engineering problems	Completely perform research literature to solve engineering problems	Comprehensively perform research literature to solve engineering problems.
Identify and analyze problems based on engineering sciences and mathematics to reach substantiated conclusions **(C4)**	Minimum identification of problems based on engineering sciences and mathematics to reach substantiated conclusions.	Limited ability to identify problems based on engineering sciences and mathematics to reach substantiated conclusions.	Satisfactorily identify problems based on engineering sciences and mathematics to reach substantiated conclusions.	Completely identify problems based on engineering sciences and mathematics to reach substantiated conclusions.	Comprehensively identify problems based on engineering sciences and mathematics to reach substantiated conclusions.
Formulate strategies for solving engineering problems **(C4)**	Minimum formulation of strategies for solving engineering problems	Limited ability to formulate strategies for solving engineering problems	Satisfactorily formulate strategies for solving engineering problems	Completely formulate strategies for solving engineering problems	Comprehensively formulate strategies for solving engineering problems
Evaluate the strategies/ solution in terms of feasibility, impact and risk (**C5)**	Minimum evaluation of the solution in terms of feasibility, impact and risk	Limited ability to evaluate the solution in terms of feasibility, impact and risk	Satisfactorily evaluate the solution in terms of feasibility, impact and risk	Completely evaluate the solution in terms of feasibility, impact and risk	Comprehensively evaluate the solution in terms of feasibility, impact and risk
Propose strategies/solutions for engineering problems **(C6)**	Minimum proposal of solutions to engineering problems	Limited ability to propose solutions to engineering problems	Satisfactorily propose solutions to engineering problems	Completely propose solutions to engineering problems	Comprehensively propose solutions to engineering problems

COGNITIVE DOMAIN

Table A3. Example of rubrics addressing **Cognitive Taxonomy Domain** for Design/Development of Solutions Programme Outcomes for (PO3)

PO3 Design/Development of Solutions - Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5)					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Explain the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations **(C2)**	Minimum explanation of the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Limited ability to explain the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Satisfactorily explain the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Completely explain the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Extensively explain the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations
Classify the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations **(C3)**	Minimum classification of the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Limited ability to classify the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Satisfactorily classify the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Completely classify the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Extensively classify the design process that meets appropriate consideration for public health and safety, cultural, societal, and environmental considerations
Analyze the existing design systems, components or processes, and identify opportunities for improvement or optimization **(C4)**	Minimum analysis of the existing design systems, components or processes and identify opportunities for improvement or optimization	Limited amount of analysis on the existing design systems, components, or processes, and identify opportunities for improvement or optimization	Satisfactorily analysis on the existing design systems, components or processes and identify opportunities for improvement or optimization	Complete analysis of the existing design systems, components or processes and identify opportunities for improvement or optimization	Extensive analysis of the existing design systems, components or processes and identify opportunities for improvement or optimization
Evaluate the functionality of the final engineering design **(C5)**	Minimum evaluation of the functionality of the final engineering design	Limited ability to evaluate the functionality of the final engineering design	Satisfactorily evaluate the functionality of the final engineering design	Completely evaluate the functionality of the final engineering design	Extensively evaluate the functionality of the final engineering design
Develop a method to solve engineering	Minimum development of a method to solve	Limited ability to develop a method to	Satisfactorily	Completely develop a method to solve	Extensively develop a method to solve engineering problems

problems according to design requirements and specifications **(C6)**	engineering problems according to design requirements and specifications	solve engineering problems according to design requirements and specifications	develop a method to solve engineering problems according to design requirements and specifications	engineering problems according to design requirements and specifications	according to design requirements and specifications
Integrate innovation in engineering design systems, components, or processes **(C6)**	Minimum integration of innovation in engineering design systems, components, or processes	Limited ability to integrate innovation in engineering design systems, components or processes	Satisfactorily integrate innovation in engineering design systems, components or processes	Completely integrate innovation in engineering design systems, components or processes	Extensively integrate innovation in engineering design systems, components or processes
Expand new ideas and directions for developing engineering design **(C6)**	Minimum expansion of new ideas and directions for developing engineering design	Limited ability to expand new ideas and directions for developing engineering design	Satisfactorily expand new ideas and directions for developing engineering design	Completely expand new ideas and directions for developing engineering design	Extensively expand new ideas and directions for developing engineering design

Table A4. Example of rubrics addressing cognitive taxonomy domain for Investigation Programme Outcomes (PO4)

PO4 Investigation - Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Discuss the research/investigation findings **(C2)**	Minimal ability to discuss the findings.	Ability to discuss some of the findings	Ability to adequately discuss the findings	Completely able to discuss the findings	Ability to discuss the findings comprehensively.
Choose and classify relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis **(C3)**	Minimal ability to choose and classify relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis	Limited ability to choose and classify relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis	Satisfactorily able to choose and classify relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis	Completely able to choose and classify relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis	With deep understanding, extensively chooses and classifies relevant research-based knowledge, theories, and concepts to guide their experimental design and analysis.

Select a methodology or theoretical framework to investigate a problem **(C4)**	Minimal ability to select a methodology or theoretical framework.	Select a methodology or theoretical framework that is somewhat appropriate.	Select an adequate methodology or theoretical framework.	Select a clear methodology or theoretical framework.	Select an optimal methodology or theoretical framework.
Analyze and **discuss** the research findings **(C4)**	Minimal ability to analyse and discuss the research findings.	Analyse and discuss some and discuss the research findings.	Adequately analyse and discuss the research findings.	Completely able to analyse and discuss the research findings.	Extensively able to analyse and discuss the research findings.
Conclude research/investigation findings **(C5)**	Minimal ability to conclude the findings.	Ability to conclude some findings.	Adequate ability to conclude the findings.	Completely able to conclude the findings.	Extensively able to conclude the findings.
Collect (C6) information and **identify** (C4) problems/ issues/ topics **(C6)**	Minimal relevant information and identify problems/issues/topics that may or may not require investigation.	Collect some relevant information and identify some problems/issues/topics that may or may not require investigation.	Ability to adequately collect relevant information and identify problems/ issues/ topics requiring investigation.	Collect complete relevant information and identify relevant problems /issues /topics with minimal orientation/ that require investigation.	Collect extensively relevant information and identify pertinent/critical information and problems/ issues/ topics without orientation/ supervision that require investigation.

PSYCHOMOTOR DOMAIN

Table A5. Example of rubrics addressing psychomotor taxonomy domain for Investigation Programme Outcomes (PO4)

PO4 Investigation - Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Select practical work materials. **(P1)**	Minimal ability to select practical work materials for the procedure.	Select some practical work materials. The selected materials are somewhat adequate for the procedure.	Select adequately practical work materials. The selected materials are adequate for the procedure.	Select sufficient practical work materials. The selected materials are suitable for the procedure.	Select exemplary practical work materials that are clear and concise for the procedure.
Explain the hypothesis/the research question,	Minimal ability to explain the hypothesis/the research question, including the	Explain some of the hypothesis/the research question, including the	Explain the hypothesis/research question adequately, including the	Clearly explain the hypothesis/the research question, including the	Extensively explain the hypothesis/the research question, including the

including the connection between the variables. **(P2)**	connection between variables involved.	connection between the variables.	connection between the variables.	connection between the variables.	connection between the variables.
Construct a comprehensive plan for data collection for a valid conclusion. **(P3)**	Minimal ability to construct a comprehensive plan for data collection for a valid conclusion	Limited ability to Construct a comprehensive plan for data collection for a valid conclusion	Construct a comprehensive plan satisfactorily for data collection for a valid conclusion.	Clearly able to construct a comprehensive plan for data collection for a valid conclusion	With a depth understanding able to extensively construct a comprehensive plan for data collection for a valid conclusion
Perform appropriate investigation for data collection and analysis to draw valid conclusions. **(P4)**	Minimal ability to perform appropriate investigation for data collection and analysis to draw valid conclusions.	Limited ability to perform appropriate investigation for data collection and analysis to draw valid conclusions.	Perform appropriate investigation satisfactorily for data collection and analysis to draw valid conclusions.	Clearly able to perform appropriate investigation for data collection and analysis to draw valid conclusions.	With a depth understanding, able to extensively perform appropriate investigations for data collection and analysis to draw valid conclusions.
Demonstrate and **interpret/explain** findings **(P5)**	Minimal ability to demonstrate and interpret/ explain findings and compose a conclusion.	Demonstrate and interpret/ explain some findings and compose a conclusion.	Demonstrate and interpret/ explain findings and compose a conclusion adequately.	Demonstrate and interpret/ explain findings and compose a conclusion proficiently.	Demonstrate and interpret/ explain findings and compose a conclusion comprehensively.
Organize variables involved, and **design** experimental procedural steps in accordance with safety and health regulations. **(P7)**	Minimal ability to organize variables and no ability to design experimental procedural steps in accordance with safety and health rules/regulations.	Students organize some chosen variables and design poor experimental procedural steps in accordance with safety and health regulations.	Students organize adequately chosen variables and design adequate experimental procedural steps in accordance with safety and health regulations.	Students proficiently organize all chosen variables and design proficiently experimental procedural steps in accordance with safety and health regulations.	Students skilfully organize all chosen variables and design skilfully experimental procedural steps in accordance with safety and health regulations.

COGNITIVE DOMAIN

Table A6. Example of rubrics addressing cognitive taxonomy domain for Modern Tool Usage Programme Outcomes (PO5)

PO5 Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6)					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Identify, compare and contrast the techniques used and resources available for a given	Minimal ability to identify, compare and contrast the techniques used and resources available for a	Limited ability to identify, compare and contrast the techniques used and resources available for a	Satisfactorily able to identify, compare and contrast the techniques used and resources	Completely able to identify, compare and contrast the techniques used and resources	Extensively able to identify, compare and contrast the techniques used and resources

complex engineering problem **(C2)**	given complex engineering problem	given complex engineering problem	available for a given complex engineering problem	available for a given complex engineering problem	available for a given complex engineering problem
Apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems **(C3)**	Minimal ability to apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems	Apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems with limited ability.	Satisfactorily apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems.	Completely able to apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems	Extensively able to apply relevant techniques, available resources, and modern engineering and IT tools to solve complex engineering problems
Critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools, and adjust or develop alternatives as necessary to improve the solution **(C4)**	Minimal ability to critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools and adjust or develop alternatives as necessary to improve the solution	Limited ability to critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools and adjust or develop alternatives as necessary to improve the solution	Satisfactorily able to critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools and adjust or develop alternatives as necessary to improve the solution	Completely able to critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools, and adjust or develop alternatives as necessary to improve the solution	Extensively able to critically distinguish the limitations and assumptions of the chosen techniques, resources, and modern engineering and IT tools and adjust or develop alternatives as necessary to improve the solution
Ability to **describe (C5)** and **explain** the principles and applicability of techniques, resources, and modern engineering and IT tools.	Minimal ability to describe and/or explain the principles behind and applicability of engineering tools.	Describe and/or explain some of the principles behind and applicability of engineering tools.	Describe and explain adequately the principles behind and applicability of engineering tools.	Describe and explain proficiently the principles behind and applicability of engineering tools.	Describe and explain comprehensively the principles behind and applicability of engineering tools.
Create (C6) new techniques or tools (engineering or IT) to solve complex engineering problems.	Minimal ability to identify/select/apply/create relevant tools for techniques, resources, and modern engineering and IT tools.	Identify/select/apply/create relevant tools for techniques, resources, and modern engineering and IT tools, but may not be the most relevant tools.	Identify/select/apply/create relevant tools for techniques, resources, and modern engineering and IT tools, satisfactorily relevant tools for engineering activity.	Completely able to Identify/select/apply/create relevant tools for techniques, resources, and modern engineering and IT tools for engineering activity.	Identify/select/apply/create relevant tools for techniques, resources, and modern engineering and IT tools comprehensively for engineering activity.

PSYCHOMOTOR DOMAIN

Table A7. Example of rubrics addressing psychomotor taxonomy domain for Modern Tool Usage Programme Outcomes (PO5)

PO5 Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6)					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Display an understanding of the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations **(P3).**	Display minimal ability to understand the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations.	Display limited ability to understand the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations.	Satisfactorily display an understanding of the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations.	Display a complete understanding of the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations.	Display extensive understanding of the limitations of the techniques, resources, and tools used, such as through discussion or the use of simple models or simulations.
Independently **perform** the use of appropriate tools and **display** skill in using prediction and modelling tools to solve complex engineering problems **(P4)**	Independently perform appropriate tools and display skill in using prediction and modelling tools to solve complex engineering problems with minimal ability.	Independently perform appropriate tools and display skill in using prediction and modelling tools to solve complex engineering problems with limited ability.	Independently perform appropriate tools and display skill in using prediction and modelling tools to solve complex engineering problems satisfactorily.	Independently perform appropriate tools and display skill in using prediction and modelling tools to solve complex engineering problems completely.	Independently perform appropriate tools and display skill in using prediction and modelling tools to solve complex engineering problems extensively.
Specify and demonstrate the limitations in using techniques, resources, modern engineering and IT tools and their underlying assumptions **(P5).**	Minimal ability to specify and demonstrate the limitations in using techniques, resources, modern engineering and IT tools, and their underlying assumptions.	Specify and demonstrate some **of** the limitations in using techniques, resources, and modern engineering and IT tools and their underlying assumptions.	Specify and adequately demonstrate the limitations in using techniques, resources, modern engineering and IT tools and their underlying assumptions.	Identify the limitations in using techniques, resources, modern engineering and IT tools, and their underlying assumptions.	Evaluate the limitations in using techniques, resources, and modern engineering and IT tools and their underlying assumptions competently.
Adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems **(P6).**	Minimal ability to adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems	Limited ability to adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems	Satisfactorily adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems.	Completely able to adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems	Extensively able to adapt to high levels of creativity and originality when applying techniques, resources, and engineering/IT tools to solve complex engineering problems

COGNITIVE DOMAIN

Table A9. Example of rubrics addressing **cognitive taxonomy domain** for The Engineers and Society Programme Outcomes (PO6)

PO6 The Engineer and Society - Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7)

Indicator (Domain)	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Apply reasoning for professional solutions with considerations **(C3)**	Apply minimal reasoning for professional solutions to engineering problems.	Apply some reasoning for professional solutions to engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Apply satisfactory reasoning for professional solutions to engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Apply adequate reasoning for professional solutions to engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Apply excellent reasoning for professional solutions to engineering problems, considering societal, health, safety, legal and/or cultural contexts.
Identify issues/ impacts/ risks on societal, health, safety, legal and/or cultural contexts **(C4)**	Identify minimal issues/impacts/risks related to societal, health, safety, legal and/or cultural contexts	Identify some issues/impacts/ risks related to societal, health, safety, legal and/or cultural contexts with minimal supporting evidence/ analysis	Identify some issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with some supporting evidence/ analysis	Identify multiple issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with adequate supporting evidence/ analysis	Identify multiple issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with comprehensive supporting evidence/ analysis
Assess professional solutions with considerations **(C5)**	Ability to conduct a minimal assessment for professional solutions to engineering problems.	Some assessment of professional solutions to engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Assess professional solutions satisfactorily to the engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Adequate assessment of the professional solution to the engineering problems, considering societal, health, safety, legal and/or cultural contexts.	Adequate assessment of the professional solution to the engineering problems, considering societal, health, safety, legal and/or cultural contexts.
Evaluate relevant circumstances using codes of practice. **(C5)**	Ability to evaluate relevant circumstances/ issues in practice or case studies using a biased perspective.	Use a personal value system to evaluate relevant circumstances/ issues in practice or case study.	Evaluate satisfactorily relevant circumstances/ issues in practice or case study using a few	Evaluate relevant circumstances/ issues in practice or case study using adequate, relevant professional experiences and codes of practice.	Evaluate excellently relevant circumstances/ issues in practice or case study using relevant and wide professional experiences and codes of practice.

			relevant professional experiences.		
Explain the roles and responsibilities of engineers in public safety and health. **(C5)**	Explain and/or display with minimal understanding of engineer professionalism for public safety and health.	Explain and/or display some understanding of engineer professionalism for public safety and health.	Explain and/or display satisfactorily understanding of engineer professionalism for public safety and health.	Explain with / display good understanding of engineer professionalism for public safety and health.	Explain with / display exemplary understanding of engineer professionalism for public safety and health.
Relate (C6) the consequent responsibilities relevant to professional engineering practice. **C6**	Relate the consequent responsibilities relevant to professional engineering practice with no justification.	Relate the consequent responsibilities relevant to professional engineering practice with minimal justifications.	Relate the consequent responsibilities relevant to professional engineering practice with satisfactory justifications.	Relate the consequent responsibilities relevant to professional engineering practice with good justifications.	Relate the consequent responsibilities relevant to professional engineering practice with excellent justifications.

AFFECTIVE DOMAIN

Table A10. Example of rubrics addressing affective taxonomy domain for The Engineers and Society Programme Outcomes (PO6)

PO6 The Engineer and Society - Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7)

Indicator (Domain)	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Choose (A1)**, Discuss** (A2)**, Differentiate** (A3)**, Adhere** (A4)**, Propose** (A5) to the Code of Professional Conduct of Malaysia / Malaysian	Choose the criteria in the code of practices in managing the risks/uncertainties on the capacities of a broadly defined engineering problem dealing with societal, health, safety, legal and/or cultural contexts.	Discuss the criteria in the code of practices in managing the risks/uncertainties on the capacities of a broadly defined engineering problem dealing with	Differentiate the criteria in the code of practices in managing the risks/uncertainties on the capacities of a well-defined engineering problem dealing with societal,	Adhere to the code of practices in managing the risks/uncertainties on the capacities of a well-defined engineering problem dealing with societal, health, safety, legal and/or cultural contexts.	Propose a solution in accordance with the code of practices in managing the risks/uncertainties on the capacities of a complex engineering problem dealing with

Laws and Regulations/ Occupational Safety and Health Administration appropriate codes, laws, standards, or regulations (**A3)**		societal, health, safety, legal and/or cultural contexts.	health, safety, legal and/or cultural contexts.		societal, health, safety, legal and/or cultural contexts.
Relate the consequent responsibilities relevant to professional engineering practice **(A4)**	Relate the consequent responsibilities relevant to professional engineering practice with no justification.	Relate the consequent responsibilities relevant to professional engineering practice with minimal justifications.	Relate the consequent responsibilities relevant to professional engineering practice with satisfactory justifications.	Relate the consequent responsibilities relevant to professional engineering practice with good justifications.	Relate the consequent responsibilities relevant to professional engineering practice with excellent justifications.
Identify the issues/ impacts/ risks on societal, health, safety, legal and/or cultural contexts **(A4)**	Identify and/or evaluate minimal issues/impacts/risks related to societal, health, safety, legal and/or cultural contexts	Identify and/or evaluate some issues/impacts/ risks related to societal, health, safety, legal and/or cultural contexts without supporting evidence/ analysis	Identify and/or evaluate sufficient issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with some evidence/ analysis	Identify and/or evaluate multiple issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with sufficient supporting evidence/ analysis	Identify and/or evaluate multiple issues/ impacts/ risks related to societal, health, safety, legal and/or cultural contexts with comprehensive supporting evidence/ analysis.
Explain (A4) and/or **display** (A5) the roles and responsibilities of engineers in public safety and health. **(A5)**	Explain and/or display with minimal understanding of engineer professionalism for public safety and health.	Explain and/or display some understanding of engineer professionalism for public safety and health.	Explain and/or display a satisfactory understanding of engineer professionalism for public safety and health.	Explain with / display good understanding of engineer professionalism for public safety and health.	Explain with / display an exemplary understanding of engineer professionalism for public safety and health.
Follow safety procedures (A3)	Follow safety procedures with minimal awareness/ with a warning.	Follow safety procedures with some awareness/ with many reminders.	Follow safety procedures with satisfactory awareness/ with some reminders.	Follow safety procedures with good awareness/ with minimal reminders.	Follow safety procedures with excellent awareness/ with no reminders.
Organise activities in the workplace complying with safety procedures (A4)	Minimal contribution to organisation of activities in the workplace, complying with safety procedures.	Some contribution to organisation of activities in the workplace, complying with safety procedures.	Satisfactory contribution to organisation of activities in the workplace, complying with safety procedures.	Good contribution to organisation of activities in the workplace, complying with safety procedures.	Excellent contribution to organisation of activities in the workplace, complying with safety procedures.

COGNITIVE DOMAIN

Table A11. Example of rubrics addressing cognitive taxonomy domain for Environment and Sustainability Programme Outcomes (PO7)

PO7 Environment and Sustainability - Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts. (WK7);					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Demonstrate engineers' responsibility for interventions on sustainability, society and the environment **(C3).**	Demonstrate minimal engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate some engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate satisfactory engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate good engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate strong engineering practices and responsibilities of interventions on sustainability, society and the environment.
Identify and **evaluate** the sustainability and impact of professional engineering work in societal and environmental contexts **(C5)**	Identify minimal sustainability and the impact of professional engineering work in solving engineering problems in societal or environmental contexts.	Identify some facts on sustainability and the impact of professional engineering work in solving engineering problems in societal or environmental contexts.	Satisfactorily identify and evaluate the sustainability and impact of professional engineering work in solving engineering problems in societal and environmental contexts.	Identify and evaluate proficiently the sustainability and impact of professional engineering work in solving engineering problems in societal and environmental contexts.	Identify and evaluate excellently the sustainability and impact of professional engineering work in solving engineering problems in societal and environmental contexts.
Propose and **recommend** sustainable materials, systems, processes, and technologies considering societal and environmental contexts. **(C6)**	Select 1 sustainable material, system and/or process in solving engineering problems in societal and environmental contexts with minimal justification.	Classify 1-2 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with some justification.	Propose/ recommend 1 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with satisfactory justification.	Propose/ recommend 2 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with good justification.	Propose/ recommend 3 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with excellent justification.

AFFECTIVE DOMAIN

Table A12. Example of rubrics addressing affective taxonomy domain for Environment and Sustainability Programme Outcomes (PO7)

PO7 Environment and Sustainability - Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts. (WK7);					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Demonstrate engineers' responsibility for interventions on sustainability, society and the environment **(A3)**	Demonstrate minimal engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate some engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate satisfactory engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate good engineering practices and responsibilities of interventions on sustainability, society and the environment.	Demonstrate strong engineering practices and responsibilities of interventions on sustainability, society and the environment.
Accommodate sustainability objectives/goals **(A4)**	Choose sustainability goals in the proposed solution.	Discuss sustainability goals in the proposed solution.	Accommodate 1 sustainability goal in the proposed solution with justification.	Accommodate 2 sustainability goals in the proposed solution with justifications.	Accommodate > 2 sustainability goals in the proposed solution with justifications.
Propose sustainable materials, systems, processes, and technologies considering societal and environmental contexts **(A5)**	Select 1 sustainable material, system and/or process in solving engineering problems in societal and environmental contexts with minimal justification.	Classify 1-2 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with some justification.	Propose 1 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with satisfactory justification.	Propose 2 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with good justification.	Propose 3 sustainable materials, systems and/or processes in solving engineering problems in societal and environmental contexts with excellent justification.

AFFECTIVE DOMAIN

Table A13. Example of rubrics addressing affective taxonomy domain for Ethics Programme Outcomes (PO8)

PO8 Ethics - Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7)					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Acclaims ethical and professional behaviour that guides the professional practice and services of engineers to the community **(A2).**	Very poor reflection on ethical and professional behaviours (Attendance, punctuality, plagiarism)	Poor reflection on ethical and professional behaviours (Attendance, punctuality, plagiarism)	Acceptable demonstration of ethical and professional behaviours (Attendance, punctuality, plagiarism)	Good demonstration of ethical and professional behaviours (Attendance, punctuality, plagiarism)	Excellent demonstration of ethical and professional behaviours (Attendance, punctuality, plagiarism)
Demonstrate ethical behaviour and originality and display exceptional recognition of the need to accept personal responsibility and the community **(A3).**	Lack of creativity, originality and/or effort in understanding the problem. Show some initiative when stimulated.	Shows little creativity, originality and/or effort in understanding the problem. The content provided has less creativity.	Adequate original touches enhance the project to show some understanding of the problem. Part of ideas/content is conceived independently.	Thoughtfully and uniquely presented; creative at times in showing understanding. Have the initiative to provide content independently.	Exceptionally creative and unique in showing deep understanding. Always have the initiative to provide content independently.
Organise (A4) regularly responsible, systematic and proactive by reporting with integrity on complex engineering activities with factual accuracy. **(A4)**	Report with a low level of integrity with few factual inaccuracies. Extensive feedback sessions are required due to minimal improvement.	Report with some level of integrity with some factual accuracy. Many feedback sessions are required since some improvement was made.	Report with a good level of integrity and moderate substantial factual accuracy. Regular feedback sessions are needed to lead to reasonable improvement.	Report with a substantial level of integrity and substantial factual accuracy. Some feedback sessions were needed, which led to good improvement.	Report with a high level of integrity and high factual accuracy. The amount of feedback needed was minimal, thus yielding excellent improvements.
Practise regularly responsible, systematic and proactive by reporting with integrity on complex engineering activities with factual accuracy. **(A5)**	Report with a low level of integrity with few factual inaccuracies. Extensive feedback sessions are required due to minimal improvement.	Report with some level of integrity with some factual accuracy. Many feedback sessions are required since some improvement was made.	Report with a good level of integrity and moderate substantial factual accuracy. Regular feedback sessions are needed to lead to reasonable improvement.	Report with a substantial level of integrity and substantial factual accuracy. Some feedback sessions were needed, which led to good improvement.	Report with a high level of integrity and high factual accuracy. The amount of feedback needed was minimal, thus yielding excellent improvements.

Display professional ethics and responsibilities of engineering practice ethics in a working environment related to engineering practices **(A5)**	Unable to display professional ethics and responsibilities in engineering practices	Display poor professional ethics and responsibilities in engineering practices.	Able to display good professional ethics and responsibilities in engineering practices.	Able to display good professional ethics and responsibilities in engineering practices.	Able to display holistic professional ethics and responsibilities in engineering practices.

AFFECTIVE DOMAIN

Table A14. Example of rubrics addressing affective taxonomy domain for Individual and Teamwork Programme Outcomes (PO9)

PO9 Individual and Teamwork - Function effectively as an individual, and as a member or leader in diverse teams and multidisciplinary settings					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Awareness, willingness to hear (A1) **Attends** safety briefing & signing 'Aku Janji' and using appropriate attire suitable for conducting lab	Attire is unsuitable for conducting the lab, does not attend the safety briefing, and does not sign 'Aku Janji.'	Attire is suitable for conducting lab but does not attend a safety briefing, only signed 'Aku Janji.'	Attire is suitable for conducting lab and attending safety briefing & signing 'Aku Janji', and showed satisfactory conduct in the lab.	Attire is suitable in conducting the lab, attended safety briefing & signed 'Aku Janji', and showed good conduct in the lab.	Attire is suitable in conducting the lab, attended safety briefing & signed 'Aku Janji' and showed excellent conduct in the lab.
[Responding to phenomena: Active participation on the part of the learners] (A2) Know- how to apply and operate modern engineering/machines/ tools. Properly handle equipment and obey the standard operating procedure;	Failed to operate/use modern machines/tools properly and did not obey the standard operating procedure (SOP), weak in giving/responding to instructions in handling equipment and safety instructions	Poor to operate/use modern machines/tools properly and do not obey the standard operating procedure (SOP), responding only through guided instructions in handling equipment and safety instructions	Adequately know how to operate/use modern machines/ tools properly and fairly obey the standard operating procedure (SOP), respond fairly to instructions in handling equipment and safety instructions	Good know-how to operate/use modern machines/ tools properly and obey the standard operating procedure (SOP), good in giving/responding to instructions in handling equipment and safety instructions	Excellently know how to operate/use modern machines/ tools properly and obey the standard operating procedure (SOP); good in giving/responding to instructions in handling equipment and safety instructions
Demonstrates function as Individual, Teamwork (A3) Function effectively as an individual and team member; enthusiastic, prepared and proactive.	Not function as an individual and as a member of a team. No enthusiasm. Failed to show and play the role of leader/ team member.	Function poorly as an individual and as a member of a team. Minimal enthusiasm. Poorly show and play the role of leader/ team member.	Function satisfactorily as an individual and as a member of a team. Shows some enthusiasm. Adequately show and play the role of leader/ team member.	Function enthusiastically as an individual and as a member of a team. Show and play the role of leader/ team member.	Function excellently as an individual and as a member of a team. Very enthusiastic. Excellently show and play the role of leader/ team member.

Bring together different values. Relating & synthesizing values and 5S (A4) Organizes values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system Discipline of an individual in terms of punctuality and obey to instructions in handling the equipment and following the safety instruction.	No plan, no delegation, and not delivering the job in conducting experiments and cleaning the workplace after the experiment (5s).	Lack of ability to plan, delegate and deliver the job in conducting experiments and cleaning the workplace after the experiment (5s).	Adequately plan, delegate and deliver the job in conducting experiments and cleaning the workplace after the experiment (5s).	Good plan, delegate and deliver the job in conducting experiments and cleaning the workplace after the experiment (5s).	Excellently plan, delegate and deliver the job in conducting experiments and cleaning the workplace after the experiment (5s).
Internalizing values (characterization). Demonstrates Leadership (A5) (i) Mentors and accepts mentoring from others (ii) Demonstrates capacity for initiative while respecting other's roles (iii) Facilitates others' involvement. (iv) Evaluates team effectiveness and plans for improvements.	Demonstrates no leadership skills.	Demonstrates some leadership skills at times.	Demonstrates adequate leadership skills.	Demonstrates good leadership skills.	Exemplifies leadership skills.

AFFECTIVE DOMAIN

Table A15. Example of rubrics addressing affective taxonomy domain for Communication Programme Outcomes (PO10)

PO10 Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Awareness, willingness to hear (A1) Ability to attend talks and seminars and to receive information given during the talk	Minimal attendance Attendance < 70%	Poor attendance Attendance between 70 to < 80%	Adequate attendance Attendance between 80 to < 90%	Good attendance Attendance between 90 – 99.9%	Excellent attendance Attendance 100%
[Responding to phenomena: Active participation on the part of the learners] (A2) Ability to **communicate** with related parties (supervisors, lab technicians, lab members etc.) in engaging each project activity to achieve desired results and effectively present the result in the report.	Minimal ability to organize the report "and to interpret and analyse data as well as report results due to no or" poor communication with related parties to understand and perform whole projects research activities, thus failing to achieve project objectives.	Poor ability to organize the report "and to interpret and analyse data and report results. However, the effort to interpret, analyse data, and present the result is shown.	Adequate ability to interpret and analyse data and report results; and demonstrate adequate communication and effort to perform each project activity and achieve project objectives.	Proficient ability to interpret, analyse the data and report results clearly; and demonstrate good communication and effort to perform each project activity and achieve project objectives.	*Excellent* ability to outstandingly interpret and analyse data and present concise and comprehensive results; demonstrate excellent communication, understanding of the research needs and effort to complete each project activity, successfully achieving all project objectives.
Valuing Communication through written reports (A3) Ability to **deliver effective reports and design documentation** to show that students could comprehend and communicate effectively on research activities	Minimal ability to coherently report research activities and findings with the underlying logic. The reader has to make a great effort to understand the underlying logic and the flow of ideas.	Poor ability to report research activities and findings with the underlying logic. The reader has to make considerable effort to understand the underlying logic and the flow of ideas, thus requiring major improvements.	Adequate ability to report research activities and findings with the underlying logic. All the research activities and findings are fairly written with underlying logic but require minor improvements.	Proficient ability to coherently report research activities and findings with the underlying logic. All the research activities and findings are fairly written with an underlying logic.	Excellent ability to report all the research activities and findings with the underlying logic and easy-to-follow writing structures.

with the engineering community (supervisors, external examiners) and with society at large.					
Valuing Communication through presenting reports (A3) Ability to **present achieved and documented findings** with the engineering community, showing effective communication and execution of engineering research activities	Minimal ability to present each research activity and project finding due to lack of understanding and minimal use of diagrams and tables to deliver comprehensive discussion and conclusion of the research project	Lack of ability to present basic research activities and project findings due to shallow understanding and minimal use of modern tools to create diagrams and tables to deliver comprehensive discussion and conclusion of the research project.	Adequate ability to present each research activity and project finding due to moderate understanding and use of modern tools to create diagrams and tables to deliver comprehensive discussion and conclusion of the research project.	Proficient ability to present each research activity and project finding due to good understanding and use of modern tools to create diagrams and tables to deliver comprehensive discussion and conclusion of the research project.	Excellent ability to effectively present each research activity and project finding due to excellent understanding and uses of modern tools to create diagrams and tables to deliver comprehensive discussion and conclusion of the research project.

COGNITIVE DOMAIN

Table A16. Example of rubrics addressing cognitive taxonomy domain for Project Management and Finance Programme Outcomes (PO11)

PO11 Project Management and Finance - Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments;					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Practise project planning: (i) identify tasks, (ii) estimate time on task, (iii) establish milestones, (iv) financial aspects and (v) manage tasks using appropriate tools **(C3)**	Practice minimal project planning as a team member to meet client expectations by fulfilling 1/5 item.	Practice some project planning as a team member to meet client expectations by fulfilling 2/5 items.	Satisfactory practice project planning as a team member to meet client expectations by fulfilling 3/5 items.	Practice good project planning as a team member to meet client expectations by fulfilling 4/5 items.	Practice excellent project planning as a team member to meet client expectations by fulfilling 5/5 items.
Estimate construction cost with relevant schedules and list of works **(C5)**	Estimate the construction cost with minimal schedules and a list of works relevant to drawings and specifications.	Estimate the construction cost with some schedules and a list of works relevant to drawings and specifications.	Estimate the construction cost with satisfactory schedules and a list of works relevant to drawings and specifications.	Estimate the construction cost with good schedules and a list of works relevant to drawings and specifications.	Estimate the construction cost with complete schedules and a list of works relevant to drawings and specifications.

Assess project performance (time, cost, risks and scopes etc.) with causes and/or consequences **(C5)**	Explain minimal aspects of project performance without relating to causes and/or consequences.	Explain minimal aspects of project performance with unrelated causes and/or consequences.	Assess some aspects of project performance with possible causes and/or consequences.	Assess good aspects of project performance with possible causes and/or consequences.	Assess excellently aspects of project performance with critical causes and/or consequences.
Integrate economic decision-making in engineering projects **(C6)**	Integrate economic decision-making principles/models/frameworks in managing projects with minimal analysis.	Integrate economic decision-making principles/models/frameworks in managing projects with some analysis.	Integrate economic decision-making principles/models/frameworks in managing projects with satisfactory analysis.	Integrate economic decision-making principles/models/frameworks in managing projects with good analysis.	Integrate economic decision-making principles/models/frameworks in managing projects with comprehensive analysis.
Relate solutions with engineering management principles in a multidisciplinary project **(C6)**	Relate solutions with minimal and irrelevant engineering management principles in a multidisciplinary project.	Relate solutions with some irrelevant engineering management principles in a multidisciplinary project.	Satisfactorily relate solutions with relevant engineering management principles in a multidisciplinary project.	Relate solutions with good and relevant engineering management principles in a multidisciplinary project.	Relate solutions with excellent and relevant engineering management principles in a multidisciplinary project.
Arrange for project planning, execution and monitoring **(C6)**	Arrange research/project activities according to research chronology, but no execution and monitoring of the implementation plan.	Arrange for research/project activities according to research chronology with some execution and monitoring of the implementation plan.	Satisfactorily arrange research/project activities according to research chronology, execute and monitor the implementation plan with appropriate adjustments.	Good arrangement of research/project activities according to research chronology, execute and monitor the implementation plan with appropriate adjustment.	Excellent arrangement of research/project activities according to research chronology, execute and monitor the implementation plan appropriate adjustment.

AFFECTIVE DOMAIN

Table A17. Example of rubrics addressing affective taxonomy domain for Project Management and Finance Programme Outcomes (PO11)

PO11 Project Management and Finance - Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments;					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Assess project performance (time, cost, risks and scopes etc.) with causes and/or consequences **(A4)**	Explain minimal aspects of project performance without relating to causes and/or consequences	Explain minimal aspects of project performance with unrelated causes and/or consequences	Assess a few aspects of project performance with possible causes and/or consequences	Assess some aspects of project performance with possible causes and/or consequences	Assess various aspects of project performance with critical causes and/or consequences
Practise project planning: (i) identify tasks, (ii) estimate time on task, (iii) establish milestones, (iv) financial aspects and (v) manage tasks using appropriate tools **(A5)**	Practice minimal project planning as a team member to meet client expectations by fulfilling 1/5 item.	Practice some project planning as a team member to meet client expectations by fulfilling 2/5 items.	Practice satisfactory project planning as a team member to meet client expectations by fulfilling 3/5 items.	Practice good project planning as a team member to meet client expectations by fulfilling 4/5 items.	Practice excellent project planning as a team member to meet client expectations by fulfilling 5/5 items.
Integrate economic decision-making in engineering projects **(A4)**	Integrate economic decision-making principles/model/framework in managing projects with minimal analysis.	Integrate economic decision-making principles/model/framework in managing projects with some analysis.	Integrate economic decision-making principles/model/framework in managing projects with satisfactory analysis.	Integrate economic decision-making principles/model/framework in managing projects with good analysis.	Integrate economic decision-making principles/model/framework in managing projects with comprehensive analysis.
Relate solutions with engineering management principles in a multidisciplinary project **(A4)**	Relate solutions with minimal and irrelevant engineering management principles in a multidisciplinary project.	Relate solutions with some irrelevant engineering management principles in a multidisciplinary project.	Satisfactorily relate solutions with relevant engineering management principles in a multidisciplinary project.	Relate solutions with good and relevant engineering management principles in a multidisciplinary project.	Relate solutions with excellent and relevant engineering management principles in a multidisciplinary project.

Arrange for project planning, execution and monitoring **(A4)**	Arrange for research/project activities according to research chronology, but no execution and monitoring of the implementation plan.	Arrange for research/project activities according to research chronology with some execution and monitoring of the implementation plan.	Satisfactorily arrange research/project activities according to research chronology, execute and monitor the implementation plan with appropriate adjustments.	Good arrangement of research/project activities according to research chronology, execute and monitor the implementation plan with appropriate adjustment.	Excellent arrangement of research/project activities according to research chronology, execute and monitor the implementation plan appropriate adjustment.

COGNITIVE DOMAIN

Table A18. Example of rubrics addressing cognitive taxonomy domain for Life-Long Learning Programme Outcomes (PO12)

PO12 Life-Long Learning - Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.					
Indicator (Domain)	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Demonstrate needs in life-long learning **(C3)**	Demonstrate less interest and no idea contributed to solving a given task	Demonstrate interest and ideas in solving a given task	Demonstrate interest, initiative, and ideas with less effort in solving a given task	Demonstrate interest, initiative, effort and ideas in solving a given task	Demonstrate excellent interest, initiative, effort and ideas in solving a given task
Independency/Self-directed **(C4)**	Explain the need for but have no preparation or ability to engage in independent and life-long learning / Unable to work independently and need full guidance	Explain the need for, but lack the preparation and ability to engage in independent and life-long learning in the limited context of technological change	Explain the need for, and have the preparation and ability to engage in independent and life-long learning in the limited context of technological change	Explain the need for, but lack the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	Explain the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Knowledge transfer **(C4)**	References are merely from a website. No citations in the text. References include articles from websites, books, newspapers and	References include articles from websites, books, newspapers and magazines and 5 to 6 articles from non-refereed/refereed	Some citations are missing. References include articles from websites, books, newspapers and magazines and 7 to 8 from non-	Citations are included, but some are wrongly cited. References more than eight (8) from non-refereed/refereed proceedings of conferences and 3 to 4 from refereed journals.	Citations are included and consistent with references. Excellent citations and references include more than eight (8) from non-refereed/refereed proceedings and

	magazines. Most of the citations are missing.	proceedings of conferences.	refereed/refereed proceedings of conferences and 1 to 2 from refereed journals.		more than five (5) refereed journals.
Curiosity/ Commitment **(C4)**	Does not offer commitment towards research progress, providing little insight and/or information beyond the very basic facts indicating low interest in the subject.	Demonstrate commitment by offering ideas or concepts occasionally, showing a lack of preparation during meetings and task execution.	Moderately demonstrates commitment by offering helpful ideas and concepts, shows moderate preparation during meetings and task execution/ indicating mild interest in the subject.	Frequently demonstrates commitment by offering helpful ideas or concepts, showing massive preparation during meetings and task execution/information indicating interest in the subject	Frequently demonstrates intense commitment by offering helpful ideas and concepts, shows wise preparation during meetings and tasks execution/ yielding a rich awareness and/or little-known information indicating intense interest in the subject.
Initiative **(C4)**	Off task, unfocused and does not do anything	Avoids challenges and always shows limited interest in doing works	Responds to challenges occasionally and shows interest in expanding knowledge, skills and abilities and curiosity in doing work.	Frequently responds to challenges and shows interest in expanding knowledge, skills, abilities and curiosity in doing work.	Respond passionately to challenges and generates and pursue opportunities to expand knowledge, skills, and abilities. Shows high curiosity in doing work.
Literature Review (Curiosity and passion) **(C6)**	Propose the research topic at the surface level, providing little insight/ information beyond the very basic facts indicating low interest in the subject.	Discusses the research topic with some evidence of depth, providing occasional insight and/or information indicating mild interest in the subject.	Interprets the research topic in-depth, yielding insight and /or information indicating moderate interest in the subject.	Proposes the research topic in-depth, yielding a rich awareness and/or little-known information indicating intense interest in the subject.	Assesses the research topic in-depth, yielding a rich awareness with high-level information indicating intense interest in the subject.
Engage independently in completing the given task or project **(C6)**	Explain the task only with step-by-step guidance	Explain the task with close guidance	Explain the task with minimum guidance	Explain the task independently	Explain the tasks beyond expectation and independently

AFFECTIVE DOMAIN

Table A19. Example of rubrics addressing affective taxonomy domain for Life-Long Learning Programme Outcomes (PO12)

PO12 Lifelong Learning - Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.					
Indicator (Domain)	**Level 1** **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Engage independently in completing the given task or project (A4)	Show minimal interest or effort in expanding their knowledge or skills	Show some interest in acquiring new knowledge or skills, but their efforts may be sporadic or limited.	Actively participate in learning activities and demonstrate a genuine interest in expanding their knowledge and skills	demonstrate a proactive approach to continuous learning, actively seeking out new knowledge, skills, and experiences.	• Assesses the research topic in-depth, yielding a rich awareness with high-level information indicating intense interest in the subject. • Demonstrate high curiosity, initiative, and enthusiasm in expanding their knowledge and skills.
Independency/Self-directed (A3)	Rely heavily on external guidance or lack the drive to explore new areas of knowledge.	Demonstrate some initiative in exploring new topics but may require external support or direction.	Actively seek out relevant resources, set personal learning goals, and create a structured approach to their independent learning endeavours.	Proactively identify areas of interest, set challenging learning goals, and consistently engage in self-directed learning activities.	Actively seek out diverse and challenging learning opportunities, continuously reflect on their progress, and adjust to optimize their self-directed learning experience.
Demonstrate needs in life-long learning (A3)	Demonstrate less interest and fewer ideas in solving a given task	Demonstrate interest and ideas in solving a given task	Demonstrate interest, initiative, and ideas with less effort in solving a given task	Demonstrate interest, initiative, effort and ideas in solving a given task	Demonstrate excellent interest, initiative, effort and ideas in solving a given task
Knowledge transfer (A3)	References are merely from websites. No citations in the text. References include articles from websites, books, newspapers and magazines. Most of the citations are missing.	References include articles from websites, books, newspapers and magazines and 5 to 6 articles from non-refereed/refereed proceedings of conferences.	Some citations are missing. References include articles from websites, books, newspapers and magazines and 7 to 8 from non-refereed/refereed proceedings of conferences and 1 to 2 from refereed journals.	Citations are included, but some are wrongly cited. References more than eight (8) from non-refereed/refereed proceedings of conferences and 3 to 4 from refereed journals.	Citations are included and consistent with references. Excellent citations and references include more than eight (8) from non-refereed/refereed proceedings and more than five (5) refereed journals.
Knowledge transfer (A3)	Have difficulty connecting what they have learned with real-	Show a basic understanding of applying their learning in different	Can identify and adapt their learning to practical scenarios and	Demonstrate a strong ability to analyse, synthesize, and integrate their knowledge, and	Apply their learning in complex and novel situations, demonstrating a

	world applications or fail to articulate and share their knowledge effectively.	contexts but may require additional guidance or practice to enhance their transferability skills.	communicate their knowledge effectively to others, demonstrating a moderate level of transferability.	are capable of effectively sharing and communicating their expertise with others.	deep understanding of the underlying concepts and principles.
Commitment (A3)	Does not offer commitment towards research progress, providing little insight and/or information beyond the very basic facts indicating low interest in the subject.	Demonstrate commitment by offering ideas or concepts occasionally, and show a lack of preparation during meetings and task execution.	Moderately demonstrates commitment by offering helpful ideas and concepts, shows moderate preparation during meetings and task execution/ indicating mild interest in the subject.	frequently demonstrates commitment by offering helpful ideas or concepts, show massive preparation during meetings and task execution/information indicating interest in the subject	Frequently demonstrates intense commitment by offering helpful ideas and concepts, shows wise preparation during meetings and tasks execution/ yielding a rich awareness and/or little-known information indicating intense interest in the subject.
Commitment (A3)	Show little dedication or persistence in their lifelong learning pursuits.	Show moderate dedication and persistence in their lifelong learning pursuits.	Maintain a regular learning routine and actively pursue their learning goals with dedication and persistence.	Consistently maintain a structured learning routine, actively pursue their learning goals, and persistently engage in continuous learning activities.	Consistently invest time, effort, and resources into their learning journey, continuously setting and achieving ambitious learning goals.
Initiative (A5)	Off task, unfocused and does not do anything.	Avoids challenges and always shows limited interest in doing works	Responds to challenges occasionally and shows some interest in expanding knowledge, skills and abilities and curiosity in doing work	Responds to challenges and shows interest identifies and pursues opportunities to expand knowledge, skills, and abilities. Moderates curiosity in doing works	Respond passionately to challenges and generates and pursue opportunities to expand knowledge, skills, and abilities. Shows high curiosity in doing works

Note: The suggested verb can be replaced with other verbs in the same domain at an appropriate level (See Table 6, Table 7 and Table 8). In case*, the user can use the verbs Apply (C3) or Identify (C4) or Describe (C2) or Evaluate (C5) or Integrate (C6) etc. It is suggested to place only one (the dominant) difficulty level at criteria, even if the user uses more than one verb, for example, Describe and Apply (C3).

2.3 Proposed Rubrics for Complex Engineering Problems and Activities

2.3.1 Introduction to Complex Engineering Problems and Activities

Engineers are hired, retained and rewarded for their abilities to solve workplace problems. If engineering programmes are to meet these challenges, they must comprehend the nature of workplace problem-solving to prepare their graduates for the workplace better. Complex problems are characterized by their lack of a clear path to a solution. Such problems often lack a clear problem statement, making the task of problem definition and problem representation quite challenging. Jonassen (1997) defined complex problems as ill-structured workplace problems: that are vaguely defined or with unclear goals and unstated constraints; they possess multiple solutions and solution paths or no consensual agreement on the appropriate solution; they involve multiple criteria for evaluating solutions; they possess no explicit means for determining appropriate actions or relationships between concepts, rules, and principles that are used; and they require learners to make judgments and express personal (individual) opinions or beliefs about the problem and defend/justify them. Complex problems can lead to multiple revisions of the problem representation to find the most appropriate solution.

2.3.2 Assessment rubrics incorporating WPs and EAs

Assessment rubrics are valuable tools that promote transparency in grading and clarify the expectations for learners' works and learning activities. Rubrics enhanced with complex engineering problems and activities promote the development of complex problem-solving skills among learners. Lecturers can develop the assessment rubrics with WPs and EAs by integrating the Graduate Attribute Rubrics and Complex Engineering Problems Rubrics in this document. This section exemplifies the integration of assessment rubrics incorporating WPs and EAs.

The EAC Standard 2020 defines seven (7) complex problem-solving attributes (WP1-WP7) and five complex engineering activities attributes (EA1-EA5), as described in Table 12.

Table 12. Descriptions for Complex Engineering Problems and Activity Characteristics

Complex Engineering Problem Characteristics	WP1 & some or all of WP2-WP7	Description of the expected graduate performance
WP1 - Depth of knowledge required **Notes:** Knowledge gained from courses/learning activities beyond the introductory instructional level	**WP1** cannot be resolved without in-depth engineering knowledge at the level of one or more of **WK3, WK4, WK5, WK6 or WK8 (WK's)** fundamental, first principles* analytical approach **Notes:** 1st Principles are the fundamental concepts/ assumptions based on a theory/system or method. In engineering, the 1st principles start directly at the level of established laws of chemistry, physics and mathematics.	WP1 is a must that requires theoretical knowledge to solve the problem/develop the design. For example, apply the theoretical knowledge from first principles to establish a workable mathematical or theoretical model or apply some standard formulae or theoretical models mixed by exposure to similar problems. Thus, the assessment requires the student to demonstrate the: ➢ ability to analyze the problem using/by applying the specified knowledge profile (WKs) and ➢ ability to evaluate the problems under such circumstances towards providing an effective solution
Range of conflicting requirements	**WP2** involves wide-ranging and conflicting technical, engineering and other issues	Some of the elements to address this characteristic are: 1. What constraints are placed to resolve the problems? 2. What conflicting demands in developing the design? 3. How were the constraints identified? - They may have been part of the brief. - They may have only become apparent once they started addressing the problem, or - The brief may be limited or only may be referenced to them loosely. The assessment requires the student to demonstrate the - ability to compare the conflicting technical, engineering, and other issues to solve the problems and - ability to assess the conflicting requirements and provide a satisfactory proposal towards solving the problems
Depth of analysis required	**WP3** have no obvious solution, abstract thinking, or originality in the analysis to formulate suitable models	- What are the guidance/constraints given to develop the solution or design? - Involve multiple solutions Approach to the development of solution/design: ➢ How was the problem defined? ➢ Students may have been given clear boundaries and specific details of what they had to do, or they may have had to define some or all of the boundaries of the problem themselves and work with limited information to decide how the work should be carried out. ➢ The problem may have been the one that they regularly encountered but with slight case-specific variations. Thus, the assessment requires the students to demonstrate the following:

		➢ Ability to develop the formulae/procedures to solve the problem using suitable models, and ➢ Justify creativity towards the achievement of the formulae/procedures
Familiarity of issues	**WP4** involve infrequently encountered issues	- To what extent is this problem routinely encountered and resolved using well-understood practices? Problems can be: 1. New problems not previously or only rarely encountered 2. A familiar problem with either: - Clearly defined methods and/or practices used to resolve - Some (or many) unique issues increased the resolution difficulty level. <u>Thus, the assessment requires the students to demonstrate the following:</u> ➢ Ability to differentiate the infrequently encountered issues in problem-solving and ➢ Select formula/procedures to resolve infrequently encountered issues
The extent of applicable codes	**WP5** is outside problems encompassed by codes for professional engineering	How to analyse/investigate or develop design by either: ➢ Applying engineering skills to address some parts of the problem that were not clearly prescribed by standards, codes or practices. ➢ Having to develop own criteria (in a manner consistent with good engineering practices) because the problem was so ill-defined that it di not fall within any specific standards, codes or codified engineering practices. <u>Thus, the assessment requires the students to demonstrate the following:</u> 1. Ability to develop solutions beyond using standards and codes of practice for professional engineering 2. Ability to justify professional engineering experiences to resolve the problems
The extent of stakeholder involvement & conflicting requirements	**WP6** involve diverse groups of stakeholders with widely varying needs	➢ How do stakeholder interests and requirements impact the problem? ➢ Are there conflicting requirements? If so, how did the students interact with the stakeholders to resolve the conflicts? ➢ Who are the stakeholders? ➢ What are their interests and requirements? ➢ The extent to which these interests of requirements conflicted and/or placed constraints on the problem. ➢ How do the students manage the stakeholders to resolve conflicts, meet their requirements or reach a satisfactory compromise? <u>Thus, the assessment requires the students to demonstrate the ability to:</u>

		1. Differentiate the diverse groups of stakeholders with widely varying needs. 2. Select stakeholder interests and requirements that give impact the problem.
Interdependence	**WP7** are high-level problems with many parts & sub-problems	The problems can be broken down into smaller components or sub-problems, not physically but mathematically. <u>Thus, the assessment requires the students to demonstrate the ability to:</u> 1. Analyze high-level problems, including many parts or sub-problems. 2. Propose the problem broken down into smaller components or sub-problems.
Complex Engineering Activity Characteristics	**Some (minimum of 2) or all EA1-EA5**	**Description of the expected graduate performance**
Range of resources	EA1: use of diverse resources (people, money, information, technologies)	What resources were available to help the students carry out these engineering activities ➢ Negotiate adequate resources, for example, personnel, funding, equipment, and authorizations to undertake work materials. ➢ Develop plans (including budgets) to schedule the availability of resources for allocation when required to meet project timeliness and financial commitments. ➢ Report work progress against schedule – workflow plans, budgets, overall project performance objectives and provide projections on work completion to target times/schedule and budget. <u>Thus, the assessment requires the students to demonstrate the ability to:</u> 1. Elaborate functions and associations with different resources such as people, money, equipment, materials, information and technologies 2. Justify the involvement of these resources in fulfilling the requirements of a successful design project.
Level of interactions	EA2: interactions between wide & conflicting technical, engineering & other issues	Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering & other issues. What unforeseen engineering issues arose during the execution of the projects? Prior to commencing the work, ensure all the engineering issues are resolved or scheduled to be resolved to meet project plan targets, i.e., identify the potential risks with the proposed solutions.

		Thus, the assessment requires the students to demonstrate the ability to: 1. Compare the conflicting technical, engineering and other issues to solve the problems. 2. Assess the conflicting requirements and provide a satisfactory proposal towards solving the problems.
Innovation	EA3: Involve creative use of engineering principles and research-based knowledge in novel ways.	What new techniques, materials, or processes can be utilized in the literature review of the project feasibility study (technical & economic)? How does the proposed approach improve work efficiency, effectiveness, or quality? Such as ROI, quality, economy, and sustainability. Thus, the assessment requires the students to demonstrate the ability to: 1. Advocate creative use of engineering principles and research-based knowledge in novel ways. 2. Justify creativity towards the achievement of novelty (e.g. patent/copyright/etc.)
Consequences to society and environment	EA4: significant consequences, characterized by difficulty of prediction & mitigation	How significant are consequences in various contexts, characterized by difficulty of prediction and mitigation? What are the impacts of engineering solutions on society and the environment? Who is/are affected, and how? Thus, the assessment requires the students to demonstrate the ability to: 1. Organize significant consequences in various contexts, characterized by difficulty of prediction and mitigation. 2. Exemplify significant consequences in various contexts, characterized by difficulty of prediction and mitigation.
Familiarity	EA5: extend beyond previous experiences using principle-based approaches	To what extent are the previous experiences routinely encountered and resolved using well-understood practices? The experience is a: 1. A new experience which is not previously or only rarely encountered 2. Familiar experiences with either: ➢ Clearly defined approaches and /or practices used to resolve. ➢ Some (or many) unique issues that mad communication difficulty level increases. Thus, the assessment requires the students to demonstrate the ability to: 1. Organise resolution beyond previous experiences routinely encountered. 2. Exemplify experiences to resolve engineering activities.

Figure 6 illustrates the minimum requirements for an assessment activity to be considered complex. To assist academicians in effectively integrating complex engineering problems and activities, we present rubrics that include attributes and indicators for WPs (Work Products) and EAs (Evidence of Achievement). These rubrics serve as guidelines for designing assessments that address complex problems and activities.

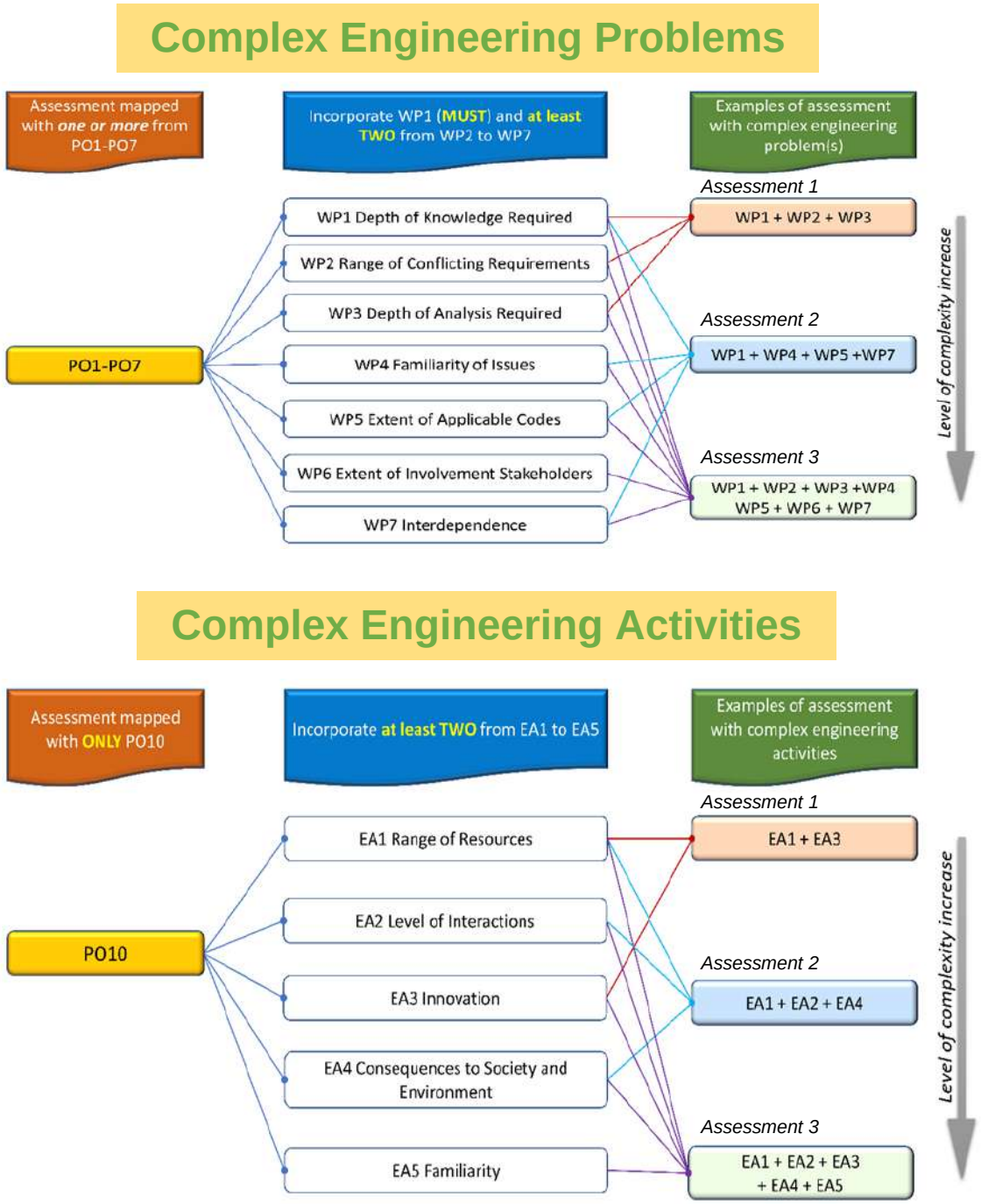

Figure 6. Illustrative examples of complex engineering problems and activities
Sample Rubrics Addressing Complex Engineering Activities

Table 13 shows the percentage distributions of assessments incorporating complex engineering problems based on academic years. Complex engineering problems are designed for the assessments with the taxonomy level of difficulty of C4 to C6 for the Cognitive domains, A3 to A5 for Affective domain and P4 to P7 for the Psychomotor domain.

Table 13. Assessment marks percentage distributions for assessment, incorporating CEP based on academic years. It also portrayed the suggested taxonomies domain and their respective difficulties.

Year	Range of Percentages (%)	Domains and Levels of Difficulties
1	5-20	Cognitive C4-C6 Psychomotor P4-P7 Affective A3-A5
2	10-30	
3	15-40	
4	25-50	

Table B1 and B2 show examples of rubrics for Complex Engineering Problem Solving Attributes and Complex Engineering Activities with their respective descriptors/indicators and levels of performances.

Table B1. Example of rubrics for Complex Engineering Problem Solving Attributes addressing the indicators and levels of performance

COMPLEX PROBLEM-SOLVING ATTRIBUTES	Indicator	WP	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Depth of Knowledge Required = in-depth engineering knowledge at the level of one or more of **WK3, WK4, WK5, WK6, or WK8** (WK's) fundamental, first principles analytical approach	**Analyse** the problem using specified knowledge profile (WKs)	**WP1 - MUST HAVE**	Use 2 WKs but do not elaborate	Use 2 WKs with acceptable elaboration	Use 3 WKs with acceptable elaboration	Use 4 WKs with acceptable elaboration	Use more than 4 WKs with acceptable elaboration
	Evaluate the problems under such circumstances to provide an effective solution.		Evaluate 1 circumstance	Evaluate 2 circumstances with acceptable justification.	Evaluate 3 circumstances with acceptable justification	Evaluate 4 circumstances with acceptable justification	Evaluate more than 4 circumstances with acceptable justification
Range of Conflicting requirement = wide & conflicting technical, engineering & other issues	**Compare** the conflicting technical, engineering and other issues to solve the problems	**WP2**	Provide only 1 issue	Compare 2 issues with acceptable discussion.	Compare 3 issues in accordance.	Compare 4 issues with acceptable discussion.	Compare more than 4 issues with acceptable discussion.
	Assess the conflicting requirements and provide a satisfactory proposal towards solving the problems.		Assess but no proposal.	Assess with 1 proposal.	Assess with 2 proposals.	Assess with 3 proposals.	Assess with more than 3 proposals.
Depth of analysis = no obvious solution, abstract thinking, originality	**Develop** the formulae/procedures to solve the problem using suitable models	**WP3**	Conceptualise 1 formula/procedure used	Conceptualise 1 formula/procedure used but do not elaborate on the model.	Conceptualise 1 formula/procedure used and elaborate the model.	Develop 2 formulas/procedures used and elaborate the model.	Develop 3 formulas/procedures used and elaborate the model.
	Justify creativity towards the achievement of the formulae/procedures.		Justify 1 creative development.	Justify the 1 creative development used but do not elaborate on the model	Justify the 1 creative development used and elaborate the model	Justify the 2 creative development used and elaborate on the model	Justify the 3 creative development used and elaborate on the model.

COMPLEX PROBLEM-SOLVING ATTRIBUTES	Indicator	WP	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Familiarity of issues = infrequently encountered issues	**Differentiate** the infrequently encountered issues in problem-solving	**WP4**	Compare the basis.	Compare and differentiate 2 issues but do not propose.	Compare and differentiate 2 issues and propose.	Compare and differentiate 3 issues and propose.	Compare and differentiate more than 3 issues and propose.
	Select formulas/procedures to resolve infrequently encountered issues.		Select 1 approach to resolve.	Select 2 approaches to resolve.	Select at least 2 approaches to resolve and justify.	Select 3 approaches to resolve and justify.	Select more than 3 approaches to resolve and justify.
The extent of applicable codes = outside problems encompassed by codes for professional engineering	**Develop** solutions using standards and codes of practice for professional engineering.	**WP5**	Use at least 1	Use at least 2	Use at least 2 and include a practising guide	Use at least 3 and include a practising guide	Use at more than 3 and include a practising guide
	Justify professional engineering experiences to resolve problems.		Justify using at least 1 experience.	Justify using at least 2 experiences.	Justify using at least 2 experiences and select at least 1.	Justify using at least 3 experiences and select at least 2.	Justify using more than 3 experiences and select at least 3.
The extent of stakeholder involvement and conflicting requirements = diverse groups of stakeholders with widely varying needs	**Differentiate** the diverse groups of stakeholders with widely varying needs	**WP6**	Compare the basis	Compare and differentiate 2 groups	Compare and differentiate 2 groups and propose 1 solution	Compare and differentiate 3 groups and propose 2 solutions	Compare and differentiate more than 3 groups and propose 3 solutions
	Select stakeholder interests and requirements that give impact on the problem.		Select 1 stakeholder and discuss the impact	Select 2 stakeholders and compare impact. Differentiate	Select 2 stakeholders and justify the impacts	Select 3 stakeholders and justify the impacts	Select more than 3 stakeholders and justify impacts
Interdependence = high-level problems with many parts & sub-problems	**Analyse** high-level problems, including many parts or sub-problems &	**WP7**	Use 2-sub problems but do not elaborate	Use 2 sub-problems with acceptable elaboration	Use 2 sub-problems and differentiate	Use 3 sub-problems and differentiate	Use more than 3 sub-problems and differentiate
	Propose the problem broken down into smaller components or sub-problems.		Propose 1 component only	Propose 1 component only	Propose 2 components with acceptable justification	Propose 3 components with acceptable justification	Propose more than 3 components with acceptable justification

Note: Improved from original rubrics in Complex Engineering Problems (WPs) And Complex Engineering Activities (EAs) and Knowledge Profile (WKs) Self-Assessment Form Version 5 developed by Prof. Ir. Dr. Siti Hawa Hamzah and Assoc Prof. Ir. Dr. Che Maznah Mat Isa, School of Civil Engineering, College of Engineering, Universiti Teknologi MARA

Table B2. A sample of rubrics addressing complex engineering activities and its respective descriptors and indicators for level of performance.

COMPLEX ENGINEERING ACTIVITIES ATTRIBUTES	Descriptors for Rubrics Design	EA (Some or all)	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Range of resources = use of diverse resources (people, money, information, technologies)	**Elaborate** functions and associations with different resources such as people, money, equipment, materials, information and technologies	**EA1**	Associate with 1 resource but no elaboration.	Associate with 1 resource with little elaboration.	Associate with 2 resources with significant elaboration.	Associate with 3 resources with significant elaboration.	Associate with more than 3 resources with very significant elaboration.
	Justify the involvement of these resources in fulfilling the requirements of a successful design project.		Justify on 1 resource only.	Justify on 1 resource with acceptable justification.	Justify on 2 resources with acceptable justification.	Justify on 3 resources with very significant justification.	Justify on more than 3 resources with very significant justification.
Level of interactions = interactions between wide & conflicting technical, engineering & other issues	**Adapt** significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues.	**EA2**	Associate with 1 level of interaction.	Adapt 1 level of interaction.	Associate with 2 levels of interaction.	Associate with 3 levels of interaction.	Associate with more than 3 levels of interaction.
	Justify the solutions achieved arising from interactions involving wide-ranging or conflicting technical, engineering or other issues.		Discuss the solutions based on the 1 level of interaction	Justify the solutions based on 1 level of interaction	Justify the solutions based on 2 levels of interaction	Justify the solutions based on 3 levels of interaction	Justify the solutions based on more than 3 levels of interaction
Innovation = creative use of engineering principles and research-based knowledge	**Advocate** creative use of engineering principles and research-based knowledge in novel ways.	**EA3**	Conceptualise only 1 creative principle used.	Conceptualise 1 creative principle used but do not elaborate on the novelty.	Advocate 1 creative principle used and elaborate on the novelty.	Advocate 2 creative principles used and elaborate on the novelty.	Advocate 3 creative principles used and elaborate on the novelty.
Innovation = creative use of engineering principles and research-based knowledge	**Justify** creativity towards the achievement of the novelty (e.g. patent/ copyright/etc.)		Justify the 1 creative principle used.	Justify the 1 creative principle used but do not elaborate on research-based knowledge.	Justify the 1 creative principle used and elaborate on research-based knowledge.	Justify the 2 creative principles used and elaborate on research-based knowledge.	Justify the 3 creative principles used and elaborate on research-based knowledge.

COMPLEX ENGINEERING ACTIVITIES ATTRIBUTES	Descriptors for Rubrics Design	EA (Some or all)	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Consequences to society and environment = significant consequences, characterized by difficulty of prediction & mitigation	**Organise** significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	**EA4**	Organise and characterise 1 context	Organise and characterise only 1 difficult context	Organise and characterise 2 difficult contexts	Organise and characterise 3 difficult contexts	Organise and characterise more than 3 difficult contexts
	Exemplify significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.		Justify the consequences	Justify (1) difficulty and its consequences	Justify (2) difficulties and their consequences	Justify (3) difficulties and their consequences	Justify the (>3) difficulties and their consequences
Familiarity = extend beyond previous experiences using principle-based approaches	**Organise** resolution beyond previous experiences routinely encountered &	**EA5**	Organise by applying 1 principle-based approach	Organise by applying 1 principles-based approach beyond previous experience.	Organise by applying 2 principles-based approaches beyond previous experience.	Organise by applying 3 principles-based approaches beyond previous experience.	Organise by applying more than 3 principles-based approaches beyond previous experience.
	Exemplify experiences in resolving the engineering activities.		Justify the approach during the resolution.	Justify the approach during resolution beyond previous experience	Justify the approaches (2) during resolution beyond previous experience.	Justify the approaches (3) during resolution beyond previous experience.	Justify the approaches (>3) during resolution beyond previous experience.

Note: Improved from original rubrics in Complex Engineering Problems (WPs) And Complex Engineering Activities (EAs) and Knowledge Profile (WKs) Self-Assessment Form Version 5 developed by Prof. Ir. Dr. Siti Hawa Hamzah and Assoc Prof. Ir. Dr. Che Maznah Mat Isa, School of Civil Engineering, College of Engineering, Universiti Teknologi MARA

2.4 Examples of Assessment Rubrics Incorporating WPs, EAs and Rubrics Addressing Knowledge Profiles (for PO without WP)

This section presents several examples of rubrics for the followings:

1) Graduate attribute assessment rubrics incorporating WP1 to WP7 and cognitive taxonomy domain. The examples of rubrics for PO1, PO2, PO3, PO4, PO5, PO6 and PO7 with relevant attributes (WKs) with their respective level of performance are shown in **Table C1 to Table C7.**

2) Graduate attribute assessment rubrics incorporating complex engineering activities EA1 to EA5 and affective taxonomy domain. The examples of rubrics presented for PO10 addressing communications are shown in **Table C8 to Table C10.**

3) Graduate attribute assessment rubrics incorporating cognitive domain rubrics addressing knowledge profiles for PO without WP for PO8, PO9 and PO12 ethics, individual and teamwork and lifelong learning are shown in **Table C11 to Table C13.**

- The graduate attribute for PO8 (Ethics) based on the EAC Standard 2020 consists of a knowledge profile, which is WK7 (comprehension). However, the graduate attribute WA7 (Ethics) from the GAPC2021 consists of a knowledge profile, WK9 (Ethics).
- The graduate attribute for PO9 (Individual & Teamwork) based on the EAC Standard 2020 contains no knowledge profile. However, the graduate attribute WA8 (Individual and Collaborative Teamwork) based on the GAPC2021 consists of a new knowledge profile, WK9 (Ethics, inclusive behaviour and conduct).
- The graduate attribute for PO12 (Lifelong Learning) based on the EAC Standard 2020 contains no knowledge profile. However, the GAPC2021 requires WA11 (Lifelong Learning) to address knowledge profile, WK8 (Research Literature). The following example shows the rubrics to measure a graduate attribute of lifelong learning with WK8.

Table C1. Example of cognitive taxonomy domain rubrics for WPs addressing Engineering Knowledge Programme Outcomes (PO1)

PO1 Engineering Knowledge - Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialisation as specified in WK1 to WK4 respectively, to the solution of complex engineering problems						
Components/Domain	**Complex Engineering Problem (WP)**	Evaluate the key problems/issues or critical limitations based on specified knowledge profiles namely: (WK3: Engineering Fundamental; WK4: Specialist Knowledge, WK6 -Engineering Practices; WK7-Comprehension and WK8 – Literature Research)				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Identify (C4) the possible cause that can create the problem that requires in-depth engineering knowledge.	**WP1: Depth of Knowledge Required** =in-depth engineering knowledge at the level of WKs	Demonstrate only one (1) specified WKs	Demonstrate only two (2) specified WKs	Demonstrate three (3) specified WKs	Demonstrate four (4) specified WKs	Demonstrate more than four (4) specified WKs
Evaluate (C5) problems with in-depth engineering knowledge	**WP1: Depth of Knowledge Required** =in-depth engineering knowledge at the level of WKs	Demonstrate only one (1) specified WKs	Demonstrate only two (2) specified WKs	Demonstrate three (3) specified WKs	Demonstrate four (4) specified WKs	Demonstrate more than four (4) specified WKs

Table C2. Example of cognitive taxonomy domain rubrics for WPs addressing Problem Analysis Programme Outcomes (PO2)

PO2 Problem Analysis - Identify, formulate, conduct research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4)						
Components/Domain	**Complex Engineering Problem (WP)**	Systematic research literature review interdependence with many parts: (1) **compile** comprehensive literature search relevant, important, and up-to-date to the subject area, (2) **analyse, evaluate** and **integrate** the previous findings and **conclude**, (3) **organise** literature according to themes and by developing sub-topics, (4) **justify** why research should be conducted, (5) **organise** citations and **compile** bibliography correctly.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Literature review (C5)	**WP7: Interdependence** = high-level problems with many parts or sub-problems	Minimal literature review.	Some literature review interdependence with 1-2 parts adequately.	Satisfactory literature review interdependence with 1-2 parts exceptionally.	Good literature review interdependence with 3-4 parts exceptionally.	Excellent literature review interdependence with all parts exceptionally.

Table C3. Example of cognitive taxonomy domain rubrics for WPs addressing Design/Development of Solutions Programme Outcomes (PO3)

PO3 Design/Development of Solutions - Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5)						
Components/Domain	**Complex Engineering Problem (WP)**	Propose a practical and suitable design solution with justification satisfying some or all requirements in (i) safety, (ii) societal, (iii) environmental, (iv) cultural and/or (iv) economic contexts.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Propose (C6) design solutions satisfying a range of conflicting requirements.	**WP2: Range of Conflicting requirements**	Minimal practicality of the proposal and unable to relate with compliance in any requirements.	Some practicality in the proposal and justification satisfying 1 requirement.	Satisfactory proposal and justification satisfying at least 2 conflicting requirements.	Good proposal and justification satisfying at least 2 conflicting requirements.	Excellent proposal and justification satisfying at least 3 conflicting requirements.
Design (C6) according to constraints/ considerations and in accordance with multiple codes of practice.	**WP5: Extent of applicable Codes**	Perform design processes with various design constraints/considerations: (i) public health, (ii) safety, (iii) cultural, (iv) societal, (v) environmental, and (vi) economic contexts, and referring to appropriate codes of practice.				
		Imitate design processes	Some design basis and without clear design considerations. No information on the codes of practice.	Satisfactory design basis and consider 1 design constraint and design accordance with 1 code of practice.	Good design basis and justify 2 design constraints in accordance with 1-2 codes of practice.	Excellent design basis and justify 3 design considerations in accordance with > 2 codes of practice.

Table C4. Example of cognitive taxonomy domain rubrics for WPs addressing Investigation Programme Outcomes (PO4)

PO4 Investigation - Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.						
Components/Domain	**Complex Engineering Problem (WP)**	Evaluate analysis results for an investigation satisfying all conflicting requirements to provide valid conclusions.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Evaluate (**C5**) analysis results involving conflicting requirements	**WP2: Range of Conflicting requirements**	Minimal evaluation, unclear requirements to be satisfied, and unable to provide valid conclusions	Minimal evaluation, identifying limited requirements to be satisfied, and unable to provide valid conclusions	Satisfactory evaluation, identify some conflicting requirements, adequately explain, but provide irrelevant conclusions.	Good evaluation satisfying some conflicting requirements, comprehensively explained, to provide useful and valid conclusions.	Excellent evaluation satisfying all conflicting requirements, comprehensively explained, to provide useful and valid conclusions.
Design (C6, P7) research methodology or theoretical framework for investigation/ experiments in accordance with multiple codes of practice.	**WP5: Extent of applicable Codes**	**Design** research methodology or theoretical framework to investigate a complex engineering problem based on standards/ guidelines/ code of practice/ professional experiences				
		Imitate design processes	Some design basis and without clear considerations. Limited information on the codes of practice.	Adequate design basis and justify considerations in accordance with 2-3 codes of practice.	Good design basis and justify considerations in accordance with 4-5 codes of practice.	Excellent design basis and justify 3 considerations in accordance with > 5 codes of practice.

Table C5. Example of cognitive taxonomy domain rubrics for WPs addressing Modern Tool Usage Programme Outcomes (PO5)

PO5 Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6)						
Components/Domain	**Complex Engineering Problem (WP)**	Predict the behaviours of material/structure using technique/software Y with an elaboration of appropriate procedures (identify problems/concepts/variables/constraints/limitations, collect data, develop method/flowchart, create model, apply a tool, predict results etc.).				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Predict (C6) behaviours with tool/ technique using in-depth analysis	**WP3: Depth of analysis =** No obvious solution and require abstract thinking, originality in analysis	Predict minimal behaviours with simple elaborations on procedures.	Predict some behaviours with adequate elaborations on at least 1-2 procedures.	Predict satisfactory behaviours with adequate elaborations on 1-2 procedures.	Predict proficiently the behaviours with comprehensive elaborations on at least 2 procedures.	Predict excellently the behaviours with comprehensive elaborations on more than 3 procedures.

Table C6. Example of cognitive taxonomy domain rubrics for WPs addressing The Engineer and Society Programme Outcomes (PO6)

PO6 The Engineer and Society - Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7)						
Components/Domain	**Complex Engineering Problem (WP)**	Evaluate the infrequently encountered issue/problem under various circumstances related to economic, social, cultural, health, safety, legal, environmental and sustainability relevant to professional civil engineering practices towards providing effective solutions				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Evaluate (C5) infrequently encountered issues	**WP4: Familiarity with issues:** Infrequently encountered issues	No evaluation of any circumstance	Evaluate 1 circumstance with acceptable justification	Evaluate 2 circumstances with acceptable justification	Evaluate 3 circumstances with acceptable justification	Evaluate more than 3 circumstances with acceptable justification
Components/Domain	**Complex Engineering Problem (WP)**	Compare the contradicting requirements by different stakeholders and explain the nature of conflicts between the technical, engineering and other issues (due to the rules and regulations of authorities, code of professional practices, health and safety regulations, stakeholders' varying needs, etc.) relevant to the problems.				
Compare (C5) contradicting requirements.	**WP6: Extent of stakeholder involvement and conflicting requirements** = diverse groups of stakeholders with widely varying needs	**Level 1 Needs Work**	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
		Identify technical, engineering, and/or other issues with minimal explanation of the nature of conflicts.	Identify technical, engineering, and other issues with some explanation of the conflict between 2.	Compare technical, engineering, and other issues with a satisfactory explanation of the nature of the conflict between 2.	Compare technical, engineering, and other issues with a good explanation of the nature of the conflict between 3	Compare technical, engineering, and other issues with comprehensive elaboration on the nature of conflict more than 3.

Table C7. Example of cognitive taxonomy domain rubrics for WPs addressing Environment and Sustainability Programme Outcomes (PO7)

PO7 Environment and Sustainability - Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts. (WK7)						
Components/Domain	**Complex Engineering Problem (WP)**	Evaluate implications and consequences of the selected sustainable solutions in societal and/or environmental and sustainability contexts from previous professional engineering experiences beyond applicable standards and codes of practice for professional engineering with justifications to resolve the problems.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Evaluate (C5) impacts of the sustainable solutions to societal and environment contexts beyond applicable codes.	**WP5: Extent of applicable codes-** outside problems encompassed by standards and codes of practice	Identify impacts without justification on how the existing standards and codes of practice dictate the solutions.	Explain impacts with a lack of justification on how the existing standards and codes of practice dictate the solutions.	Evaluate satisfactorily the impacts with acceptable justification on how the existing standards and codes of practice dictate the solutions.	Evaluate well the impacts with good justification on how the existing standards and codes of practices dictate the solutions.	Evaluate accurately the impacts with excellent justification on how the existing standards and codes of practices dictate the solutions.

Table C8. Example 1 - Affective taxonomy domain rubrics incorporating EAs for Communication Programme Outcomes (PO10).

PO10 Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions						
Components/Domain	**Complex Problem & Knowledge Profile (WK)**	Elaborate clearly, fluently and convincingly on involvement in using diverse resources (People, money, materials, information, technologies) in research and case studies.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Demonstrate (A3)	**EA1: Range of Resources** = Involve the use of diverse resources (People, money, information, technologies)	Shows limited or incorrect use of relevant techniques or methods.	Shows an attempt at using relevant techniques or methods.	Shows adequate use of relevant techniques or methods.	Shows proficient use of relevant techniques or methods.	Shows expert use of relevant techniques or methods.
	EA3: Innovation = creatively using engineering principles and research-based knowledge in a novel way.	Limited understanding of the subject matter and lack of innovative approaches.	Some understanding of the subject matter and attempts at innovative approaches.	A reasonable understanding of the subject matter and attempts at innovative approaches.	A clear understanding of the subject matter and effective implementation of innovative approaches.	A Deep understanding of the subject matter and highly innovative approaches.
Communication Skill **Practice** (A5)	**EA1: Range of Resources** = Involve the use of diverse resources (People, money, information, technologies)	Involved only one (1) resource with a lack of explanation	Involved only two (2) resources with some elaboration	Involved three (3) resources with satisfactory elaboration	Involved four (4) resources with substantial elaboration	Involved more than four (4) resources with a detailed elaboration of each resource

	EA2: Level of interactions = interactions between wide & conflicting technical, engineering & other issues	Discuss and justify solutions arising from interactions involving wide-ranging or conflicting technical, engineering or other issues.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
		Discuss the solutions based on the 1 level of interaction	Justify the solutions based on 1 level of interaction	Justify the solutions based on 2 levels of interaction	Justify the solutions based on 3 levels of interaction	Justify the solutions based on more than 3 levels of interaction

Table C9. Example 2 - Affective taxonomy domain rubrics incorporating EAs for Communication Programme Outcomes (PO10).

PO10 Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

Components/ Domain	**Complex Problem & Knowledge Profile (WK)**	Present ideas in a logical sequence on the creative use of engineering principles and/or research-based knowledge in a novel way.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Presentation Skill **Explain** (A3)	**EA2: Level of interactions =** interactions between wide & conflicting technical, engineering & other issues	Minimal understanding of engineering principles or research-based knowledge.	Basic understanding of engineering principles or research-based knowledge.	Solid understanding of engineering principles or research-based knowledge.	Advanced understanding of engineering principles or research-based knowledge	profound understanding of engineering principles or research-based knowledge.
Compare (A4)	**EA4: Consequences to society and**	Limited or no comparison of consequences to	Partial comparison of consequences to	Reasonable recognition of the potential impacts on	Clear recognition of the potential impacts on	Exceptional recognition of the potential impacts

	environment = Highlight significant consequences characterized by difficulty of prediction and mitigation	society and environment.	society and environment.	society and the environment.	society and the environment.	on society and the environment.
Presentation Skill **Practise** (A5)	**EA3: Innovation** = creatively using engineering principles and research-based knowledge in a novel way**.**	Poor presentation of ideas, lack of creativity, and only adapting the current techniques/processes but not applicable to solve problems.	Some presentation of ideas on creatively using engineering principles and/or research-based knowledge to adapt current techniques/processes and applications to solve problems.	Satisfactory presentation of ideas on creatively using engineering principles and/or research-based knowledge to adapt current techniques/processes and applications to solve problems.	Good presentation of ideas on creatively using engineering principles and/or research-based knowledge to enhance current techniques/processes and applications to solve problems.	Excellent presentation of ideas on very creatively uses the engineering principles and/or research-based knowledge on new materials/ techniques/processes in modified (innovation)/new ways (invention).

Table C10. Example 3 - Affective taxonomy domain rubrics incorporating EAs for Communication Programme Outcomes (PO10).

PO10 Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions						
Components/Domain	**Complex Engineering Activities & Knowledge Profile (WK)**	Defend solutions highlighting significant consequences to society and the environment, characterized by difficulty of prediction and mitigation.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Discussion Q&A session	**EA2: Level of interactions =** interactions between	Does not address or highlight significant consequences to	Partially addresses significant consequences to	Highlights significant consequences to society and the	Clearly and comprehensively addresses significant	Thoroughly and insightfully examines significant

Justify (A3)	wide & conflicting technical, engineering & other issues	society and the environment.	society and the environment.	environment effectively.	consequences to society and the environment.	consequences to society and the environment.
Discussion Q&A session **Defend** (A4) **Influence** (A5)	**EA4: Consequences to society and environment** = Highlight significant consequences characterized by difficulty of prediction and mitigation	Unable to defend/respond and answer	Able to defend/respond and answer without relevancy and with hesitation	Able to defend/respond and answer with minimum relevancy and confidence	Able to defend/respond and answer clearly with significant relevancy and confidence	Able to influence with excellent defend/respond and answer very well with high relevancy (with justification) and high confidence
Suggestion **Interpret** (A5)	**Complex Problem & Knowledge Profile (WK)**	Suggest solutions by applying a principle-based approach beyond previous experiences clearly and concisely.				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
	EA5: Familiarity = Can extend beyond previous experiences by applying principles-based approaches.	applying 1 principle-based approach	by applying 1 principle-based approach beyond previous experience	by applying 2 principle-based approaches beyond previous experience	by applying 3 principle-based approaches beyond previous experience	by applying more than 3 principle-based approaches beyond previous experience

Table C11. Example of cognitive taxonomy domain rubrics addressing knowledge profiles for PO without WP.

PO8: Ethics - Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice **(WK7)** – EAC Standard 2020 **WA7**: Ethics - Understanding and level of practice: Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate understanding of the need for diversity and inclusion **(WK9)** – GAPC2021.						
Components/Domain	**Knowledge Profile**	Ability to understand and comprehend the role of engineers in society on identified issues related to ethics and professional responsibility of an engineer to public safety and impacts of engineering activities				
		Level 1 **Needs Work**	**Level 2** **Developing**	**Level 3** **Satisfactory**	**Level 4** **Competent**	**Level 5** **Excellent**
Comprehension of the role of engineers in society on identified issues related to ethics and professional responsibility (**C4**)	**WK7:** Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability	Very poor understanding and comprehension of the identified issues related to ethics and professional responsibilities	Poor understanding and comprehension of the identified issues related to ethics and professional responsibilities	Adequate understanding and comprehension of the identified issues related to ethics and professional responsibilities	Good understanding and comprehension of the identified issues related to ethics and professional responsibilities	Excellent understanding and comprehension of the identified issues related to ethics and professional responsibilities
Comprehension of the identified issues related to ethics and professional responsibility and norms of engineering practices (**C4**)	**WK9: Ethics, inclusive behaviour and conduct**. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity	No elaboration due to poor knowledge of professional ethics, responsibilities, and norms of engineering practice and very	Lack of elaboration due to a lack of knowledge of professional ethics, responsibilities, and norms of engineering practice and poor	Acceptable elaboration based on moderate knowledge of professional ethics, responsibilities, and norms of engineering practice and satisfactory	Good elaboration based on good knowledge of professional ethics, responsibilities, and norms of engineering practice and a good awareness of the need for diversity.	Elaborate well based on excellent knowledge of professional ethics, responsibilities, and norms of engineering practice and high awareness

	because of ethnicity, gender, age, physical ability etc., with mutual understanding and respect, and inclusive attitudes	poor/no awareness of the need for diversity	awareness of the need for diversity.	awareness of the need for diversity.		of the need for diversity.

Table C12. Example of affective taxonomy domain rubrics addressing PO9 and WKs. The graduate attribute for PO9 (Individual & Teamwork) based on the EAC Standard 2020 contains no knowledge profile. However, the graduate attribute WA8 (Individual and Collaborative Teamwork) based on the GAPC2021 consists of a new knowledge profile, WK9 (Ethics, inclusive behaviour, and conduct). The following example shows the rubrics to measure graduate attribute WA8 with WK9 (Ethics, inclusive behaviour, and conduct) based on GAPC2021.

PO9: Individual and Teamwork - Function effectively as an individual, and as a member or leader in diverse teams and multidisciplinary settings – EAC Standard 2020

WA8: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multi-disciplinary, face-to-face, remote and distributed settings **(WK9)** – GAPC2021

Components/Domain	Knowledge Profile	Level 1 Needs Work	Level 2 Developing	Level 3 Satisfactory	Level 4 Competent	Level 5 Excellent
Demonstration of professional ethics and behaviour and professional conduct (A4)	**WK9: Ethics, inclusive behaviour and conduct**. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity because of ethnicity, gender, age, physical ability etc., with mutual understanding and respect, and inclusive attitudes	Show very poor professional ethics and behaviour, lack of initiative, and not interested in team engagement.	Show a lack of professional ethics and responsibility by showing few initiatives to provide the needed help for team satisfaction and engagement.	Show acceptable professional ethics and behaviour through initiatives to provide the needed help for team satisfaction and engagement.	Proactive and show good professional ethics and responsibilities through good initiatives to provide the needed help for team satisfaction and engagement	Very proactive and demonstrate excellent professional ethics and responsibilities by showing great initiatives to provide the needed help for the team satisfaction and engagement

Table C13. Example of affective taxonomy domain rubrics addressing PO12 and WK8. The graduate attribute for PO12 (Lifelong Learning) based on the EAC Standard 2020 contains no knowledge profile. However, the GAPC2021 requires WA11 (Lifelong Learning) to address knowledge profile, WK8 (Research Literature). The following example shows the rubrics to measure graduate attributes of lifelong learning with WK8.

PO12/WA11 Lifelong learning: Duration and manner - Recognize the need for, and have the preparation and ability for i) independent and life-long learning, ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change **(WK8)**						
Components/Domain	**Knowledge Profile**	**Beyond classroom requirements and gain different levels of independent educational experiences**				
		Level 1 Needs Work	**Level 2 Developing**	**Level 3 Satisfactory**	**Level 4 Competent**	**Level 5 Excellent**
Independence (A4)	**WK8**: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues	Very limited to classroom requirements, showing no interest in pursuing knowledge and very dependent.	Only begins to look beyond classroom requirements, pursues additional knowledge and/or shows interest in pursuing independent educational experiences.	Beyond classroom requirements, pursues substantial, additional knowledge and/or actively pursues independent educational experiences.	Beyond classroom requirements, actively pursues substantial, additional knowledge and/or differentiates independent educational experiences.	Educational interests and pursuits exist and flourish outside classroom requirements. Knowledge and/or experiences are pursued independently.

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Appendix

Sample of rubrics are available in the following link:

https://drive.google.com/drive/u/0/folders/1FINSyqxIo0RgTq0jsz-D8MAY2WZ9V2y_