USE AND IMPORTANCE OF ASSESSMENT RUBRICS IN OUTCOME BASED EDUCATION

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Contents

OBE

- Outcome-based education or outcomes-based education (OBE) is an educational theory that bases each part of an educational system around goals (outcomes).

- Each PO must be explicitly & directly measured at least in selected subjects
- Supported by sound rubrics, marking scheme, etc.
- **ALL** PO's **MUST** be covered
- The weightage of each PO up to the IHL

CLO – PLO ASSESSMENT LINKAGE

CLO	PLO 1	PLO3	Types of Assessment
1	√		Assignment, Test, Final Exam
2		√	Test, Final Exam
3	√		Mini Project, Final Exam
4		√	Final Exam

PLO	CLO	Type of Assessment	Weightage (%)	Total Weightage for CLO (%)	Total (%)
1	1	Assignment Test 1 Final Exam (Q1)	5 10 10	25	100
	3	Mini Project Final Exam (Q2)	15 20	35	
3	2	Test 2 Final Exam (Q3)	10 10	20	
	4	Final Exam (Q4)	20	20	

Rubrics

What is a rubric?

- A rubric is typically an evaluation tool or set of guidelines
- Used to promote the consistent application of learning expectations, learning objectives, or learning standards in the classroom,
- To measure their attainment against a consistent set of criteria.
- A rubric is a learning and assessment tool that articulates the expectations for assignments and performance tasks by listing criteria, and for each criteria, describing levels of quality .

Rubrics

Rubrics contain four essential features:

1. *a task description or a descriptive title* of the task students are expected to produce or perform;
2. *a scale and scoring* that describes the level of mastery (e.g., exceed expectation, meets expectation, doesn't meet expectation);
3. *components/dimensions* students are to attend to in completing the assignment/tasks (e.g., types of skills, knowledge, etc.); and
4. *description of the performance quality* (performance descriptor) of the components/dimensions at each level of mastery.

Example of rubrics

a task description or a descriptive title					
	Unsatisfactory 1	Developing 2	Satisfactory 3	Exemplary 4	
Performance criteria					
Performance criteria					
Performance criteria					
Performance criteria					

Dimensions

Scale

Descriptors

Rubrics

A description of performance quality give students

- a clear idea about what must be done to demonstrate a certain level of mastery, understanding, or proficiency

  "excellent" does xyz,

  "fair" does only xy or yz,

  "poor" does only x or y or z).

Rubrics can be used for any assignment in a course, or for any way in which you ask students to demonstrate what they have learned. They can also be used to facilitate self and peer-reviews of student work.

Rubrics

A rubric can be

- analytic or
- holistic.

An analytic rubric articulates different dimensions of performance and provides ratings for each dimension.

A holistic rubric describes the overall characteristics of a performance and provides a single score.

Holistic rubrics

- Single criteria rubrics (one-dimensional) used to assess participants' overall achievement on an activity or item based on predefined achievement levels;
- Performance descriptions are written in paragraphs and usually in full sentences.

Example:

- **Research Paper (Holistic Rubric)**

How do we apply and adopt holistic rubrics?

Score	Criteria
4 (80-100%)	Research paper demonstrates complete understanding and execution of the assigned objectives. Thesis statement/argument is clearly stated, complex and original, and the writing does not spend excessive time on any one point of development at the expense of developing other points in the body of the paper. Writing is also error-free, without ambiguity, and reads smoothly, creatively, and with a purpose.
3 (70-79%)	Research paper demonstrates considerable understanding and execution of the assigned objectives. Thesis statement/argument is stated, verges on the complex and original, and the writing shows accuracy and balance in developing body points, but may exhibit occasional weaknesses and lapses in correctness. Writing also has some errors and ambiguities, yet does read clearly and coherently.
2 (60-69%)	Research paper demonstrates some understanding and execution of the assigned objectives. Thesis statement/argument is faintly stated and/or expected and not confident, and the writing is inconsistent in terms of balance in developing body points, and exhibits weaknesses and lapses in correctness. Writing also has many errors and ambiguities, and may read confusingly and incoherently.
1 (50-59%)	Research paper demonstrates limited understanding and execution of the assigned objectives. Thesis statement/argument is simplistic, unoriginal, and/or not present at all, and the writing is unbalanced in developing body points, weak, and incomplete. Writing also has numerous errors and ambiguities, and reads confusingly and incoherently.

Adapted from John Bean, *Engaging Ideas*, Exhibit 15.4: Holistic Scale for Grading Article Summaries (262)

Holistic rubrics

- **Advantages:**

- Emphasis on effectiveness of paper rather than ability of writer
- Less choices for assessor to make
- More intuitive to score
- Less complex, may be easier for students to understand (teaching.berkeley.e**du)**

- **Disadvantages:**

- Not conducive to feedback to weigh criteria
- Inability to weigh criteria
- May be difficult to assess when students have a wide swath of skill level

Consider using a holistic rubric when:

- Time does not allow for in-depth analysis (daily assignment)
- Emphasis is to be placed on effectiveness of piece as a whole

Analytic rubrics

- Two-dimensional rubrics with levels of achievement as columns and assessment criteria as rows. Allows you to assess participants' achievements based on multiple criteria using a single rubric. You can assign different weights (value) to different criteria and include an overall achievement by totaling the criteria;
- Written in a table form.
- Analytic rubrics offer a number of criteria (typically 4-7) in the left column with a scale of performance in the topmost column.

- **Research Paper (Analytic Rubric)**

How do we apply and adopt analytic rubrics?

	Standards			
Criteria	**Adequate** (50-59%)	**Competent** (60-69%)	**Good** (70-79%)	**Excellent** (80-100%)
Knowledge of forms, conventions, terminology, and strategies relative to the importance of sources to subject	Demonstrates limited knowledge of forms, conventions, terminology, and strategies relative to importance of sources to subject	Demonstrates some knowledge of forms, conventions, terminology, and strategies relative to importance of sources to subject	Demonstrates considerable knowledge of forms, conventions, terminology, and strategies relative to importance of sources to subject	Demonstrates thorough and insightful knowledge of forms, conventions, terminology, and strategies relative to importance of sources to subject
Critical and creative thinking skills	Uses critical and creative thinking skills with limited effectiveness	Uses critical and creative thinking skills with moderate effectiveness	Uses critical and creative thinking skills with considerable effectiveness	Uses critical and creative thinking skills with a high degree of effectiveness
Communication of information and idea	Communicates information and idea with limited clarity	Communicates information and ideas with some clarity	Communicates information and ideas with considerable clarity	Communicates information and ideas with a high degree of clarity and with confidence
Quality of argument and writing	Argument is simple and unoriginal, and the writing is weak and inconsistent	Argument takes on a fair and expected position, and the writing is moderately clear and coherent	Argument bridges on the complex and original, and the writing is clear and coherent	Argument is complex and original, and the writing is strong, fluid, and creatively coherent
Spelling and grammar	Several errors in spelling and grammar	A few errors in spelling and grammar	Some errors in spelling and grammar	No errors in spelling and grammar

Adapted from Centre for Teaching Excellence, Appendix B: Sample Analytic Rubric ("Rubrics: Useful Assessment Tools.

Analytic rubrics

Advantages:

- Highlights specific areas of strength and weakness
- Criterion can be weighted to emphasize relative importance
- Comparison of numerous rubrics may show progression
- Geared toward a more reliable means of scoring
- Supplementary use in writing process can increase writer's confidence and awareness of criteria

Disadvantages:

- Reliability depends on well-defined criterion
- No substantial proof for improvement of writing
- Effective rubrics take time, trial and error, and perseverance to create

Consider using an analytic rubric when:

- Emphasis of assessment is feedback
- Time allows for in-depth analysis of work
- Criteria needs to be explicated

Rubrics

Why Rubrics is education?

- Provide students with feedback that is clear, directed and focused on ways to improve learning.
- Demystify assignment expectations so students can focus on the work instead of guessing "what the teacher wants."
- Adapt your approach to teaching aspects of a course based on thematic gaps in student learning that are easily identified by reviewing rubrics across a class.
- Develop consistency in how you evaluate student learning across students and throughout a class.
- Reduce time spent on grading; Increase time spent on teaching.
- Increasing student dissatisfaction with assessment and feedback is an issue of international concern in higher education.
- Rubrics are viewed favourably by both staff and students as a method of enhancing consistency in assessment.

Rubrics

Rubrics help students:

- Focus their efforts on completing assignments in line with clearly set expectations.
- Self and Peer-reflect on their learning, making informed changes to achieve the desired learning level.

Getting Started with Rubrics

- STEP 1:

Clarify task/performance expectations.

- STEP 2:

Identify the characteristics of student performances. What is it that students are supposed to demonstrate (skills, knowledge, behaviors, etc.)? [components/dimensions]

- STEP 3:

Identify how many mastery levels are needed for each performance component/dimension. Decide what score should be allocated for each level. [scale]

Getting Started with Rubrics

- STEP 4:

Describe performance characteristics of each component/dimension for each mastery level. [performance descriptor]

- STEP 5:

Pilot-test the rubric with a few sample papers and/or get feedback from your colleagues (and students) on the rubric. Revise the rubric.

Developing Rubrics for Engineering Education

1. Identify the purposes and aims of assessing the students: Determine if it is for feedback and/or for certification or others.
2. Identify what you want to assess: Align them with the students' learning outcomes and objectives and learning activities.
3. Select the appropriate rubrics: Determine whether holistic rubrics or analytic rubrics are more appropriate. The selection depends on the type of assessment used and the specific results you want to provide for feedback in the outcome assessment process.
4. Identify the performance criteria that your assessment will be graded against: For example for presentation rubrics, you may have introduction, knowledge understanding, presentation delivery, posture/eye-contact and time-management.

Developing Rubrics for Engineering Education

5. Identify the type of scale to be used: Identifying an appropriate scale is essential both in terms of the number of levels and the type. For instance a scale of 1-0 will not be useful, and a scale of 10 levels will probably cause frustration for the evaluator and become too exhaustive. When adopting the use of "0" in the number scale, it is important to take precaution as a student who receives a "0" may have the tendency to feel that he or she receives a grade of "zero". It may be more useful to use scales with words such as "Excellent, Proficient, Average and Poor."
6. Describe the level of mastery: Write descriptive statement(s) for each level of performance, the difference between each level should be as equal as possible. The best way to do that is to determine the worst and the best levels, and try to fill the levels in between. In addition, the description of the levels should be objective than subjective.

   For instance, a descriptive statement like "Student's mathematical calculations contain no errors" is better than a descriptive statement like "Student's mathematical calculations are good". The first statement is preferred over the latter statement because the phrase "no errors" is quantifiable, whereas "are good" requires the evaluator to make judgment.

Developing Rubrics for Engineering Education

7. Test the rubrics: Conduct a test trial of the scale on several samples with several faculty members using the developed rubrics. In order to determine the inter-rater reliability of the rubrics, use formal statistical tests or at least draw up a rating matrix containing ratings of all raters and look for signs of reasonable consistency among all raters.
8. Put the rubrics into application: After conducting the test trials, the rubrics can be used in the formal assessment process.
9. Revise the rubrics from time to time: Discuss with fellow colleagues and students when revising the rubrics. Others opinion can offer you insights on how to improve your rubrics. Therefore it is wise to enlist the help of colleagues when developing rubrics for the assessment of a program. Rubrics function to promote shared expectations and grading practices, which can be beneficial to both faculty members and students in the programme.
10. Options: It is sometimes useful to develop the rubrics with the students, as it helps the students to understand the usefulness of rubrics and allowing transparent assessment procedures.

Developing Rubrics for Engineering Education

- Assessment of the ABET outcomes and assessment of critical thinking can be often be accomplished most effectively using **rubrics**.
- ABET defines a **rubric** as a set of categories developed from the performance criteria that define and describe progression toward meeting the components of work being completed, critiqued, or assessed.
- Many papers have emphasized the importance of critical thinking in **engineering programs** and even more demonstrate the use of rubrics for assessing the ABET outcomes. Moreover, rubrics are available that assess critical thinking in engineering and different rubrics are available that assess critical thinking using the Paul-Elder critical thinking framework. However, no rubric, either holistic or analytic, was found that assessed critical thinking in engineering education using the Paul-Elder critical thinking framework.

ABET Program Outcomes

a. an ability to apply knowledge of mathematics, science and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. an ability to function on multidisciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively (both oral and written)
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Developing Rubrics for Engineering Education

- Developing rubrics: Never an easy task because the process involves a lot of trial and error, which challenges the developer's patience. Besides developing rubrics, refinement is also crucial.
- Collaboration among teachers in the development and implementation of the rubrics is important in standardizing grading.

Criteria for demonstrating open ended problem solving

(a) Student recognizes and determines when a problem is worth solving (develops decision making criteria; justifies decisions.)

(b) Student defines (frames) problem accurately (analyses critical elements and scope of problem, focuses on issues, sorts issues according to impact on problem.)

(c) Student articulates social, economic, and technical constraints of a problem.

(d) Student devises process and work plan to solve problem (identifies critical tasks, time needed, and resources; uses organizational and management tools; divides work efficiently.)

(e) Student identifies, considers, and weighs options or consequences of plan and design (identifies analytic strategy to weigh design consequences and solutions.)

Criteria for demonstrating multidisciplinary teamwork

(f) Student negotiates various design approaches with a multidisciplinary group/team (identifies different needed disciplinary expertise to solve the problem, creates multidisciplinary team.)

(g) Student leads or follows when appropriate to the needs of the group (shares stage, offers expertise/participation when and where appropriate.)

Focus on Criteria (d)

Criteria (d): Student devises process and work plan to solve problem	
Measure	Score
fails to identify the critical tasks and actions necessary to solve problem; fails to identify and misidentifies the time and resource requirements; does not employ organizational or management tools to organize tasks and resources	?
identifies few of the critical tasks and actions necessary to solve problem; identifies few, or misidentifies the time and resource requirements; employs few organizational and management tools to organize tasks and resources	?
identifies some of the critical tasks and actions necessary to solve problem; identifies some of the time and resource requirements; sometimes employs organizational and management tools to logically and efficiently organize tasks and resources	?
identifies all critical tasks and actions necessary to solve problem; identifies most time and resource requirements; always employs organizational and management tools to logically and efficiently organize tasks and resources	?

IDP RUBRICS: UM

- Moderator: (130 marks)

PART A: Final Report (Group)

- Technical investigation and analysis (10 marks)
- Project management and economic feasibility (20 marks)
- Ethics and standard (25 marks)
- Communication (15 marks)
- Sustainability (10 marks)

- PART B: Poster & Demo Presentation (Group)
  - Technical investigation and analysis (10 marks)
  - Ethics and standard (15 marks)
  - Communication (15 marks)
  - Sustainability (10 marks)

- Supervisor (105 marks)
  - Part A: Team work (Weekly meeting: Individual) (20 marks)
  - Part B: Team work (Final report: Group) (20 marks)
  - Project management and economic feasibility (20 marks)
  - Ethics and standard (25 marks)
  - Communication (10 marks)
  - Sustainability (10 marks)

PART A: Final Report (Group)	PART B: Poster and Demo Presentation (Group)
Technical investigation and analysis (10 marks)	Technical investigation and analysis (10 marks)
Project management and economic feasibility (20 marks)	Ethics and standard (15 marks)
Ethics and standard (25 marks)	Communication (15 marks)
Communication (15 marks)	Sustainability (10 marks)
Sustainability (10 marks)	
Supervisor evaluation	
Part A: Team work (Weekly meeting: Individual) (20 marks)	Team work (Final report: Group) (20 marks)
	Project management and economic feasibility (20 marks)
	Ethics and standard (25 marks)
	Communication (10 marks)
	Sustainability (10 marks)

IDP RUBRICS: UM – Moderator's evaluation

PART A: Final Report (Group)					
Marks / Criteria	1 Very poor	2 Poor	3 Satisfactory	4 Good	5 Excellent
Technical investigation and analysis (10 marks) **WP1-7** **EA1-2,4**	Not competent at all in the technical investigations of the proposed design (No calculation, simulation and justification were given at all in the technical analysis of the proposed design)	Demonstrated poor competency in the technical investigations of the proposed design (Insufficient calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated some degree of competency in the technical investigations of the proposed design (Comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated high competency in the technical investigations of the proposed design (Highly comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated extremely high competency in the technical investigations of the proposed design (Extremely comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)
Use modern tools **WP1** **EA1**	Modern tools and basic engineering principles were not considered at all in the technical analysis of the proposed design	Poor usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated satisfactory usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated highly competent usage of modern tools and basic engineering principles in the technical analysis of the	Demonstrated extremely competent usage of modern tools and basic engineering principles in the technical analysis of the proposed design

Project management and economic feasibility (20 marks)

Risk management **EA1,2,4**	**Addresses only surface-level or obvious risks**	**Minimally explores options to mitigate risks; Only explores options for the most basic risks**	**Realistically estimates the probability and severity of all risks identified**	**Selects mostly ppropriate mitigating actions; Somewhat considers the prior risk identification and assessment**	**Realistically assesses all risks, considering the probability of occurrence and severity of consequences**
Schedule	Fails to include important details or to reflect the goals of project in the schedule.	Developed a schedule that omitted significant project activities/tasks	Developed a comprehensive schedule of project activities/tasks but identified unrealistic due dates	Developed a comprehensive schedule of project activities/tasks with realistic due dates	Developed an outstanding schedule that facilitates implementation and takes into account the goals of the project with realistic due dates.
Resources **EA1,2**	Insufficient resources identified for the project	Identified some resources needed for the project	Identified most resources needed for the project	Identified all resources needed for the project	Identified and managed all resources within identified constraints
Budget/cost	Missing/ incomplete/over budget	Demonstrated minimal ability to reate or adhere to a budget.	Demonstrated some ability to create and/or adhere to a budget. Budget covers most applicable areas.	Demonstrated an ability to create and/or adhere to a budget. Budget covers all applicable areas of project.	Demonstrated a skilful ability to create and/or adhere to a budget. Budget covers all applicable areas, with room for contingencies.

Ethics and Standard (25 marks)

Identify relevant standard testing procedures WP1,5,6 EA4	Very poor consideration given to relevant standard testing procedures in the design.	Group is aware of related testing procedures but limited consideration were given in its execution in the design.	Some consideration given to the relevant standard testing procedures	Ample considerations were given to related testing procedures.	Outstanding consideration given to relevant standard testing procedures which were executed in the design.
Safety and health considerations WP6 EA4	Total ignorance of safety related issues. Obvious safety problems detected in the proposed design.	The design appears to be potentially safe but the safety awareness is poorly articulated in the report; some attention seems to be given to safety.	Group recognizes and satisfactorily includes relevant safety related design issues in the proposed design.	Group usually recognizes and adequately includes relevant safety related design issues in the proposed design.	Group almost always recognizes, anticipates, and includes relevant safety related design issues. The safety aspect is included in the design in an innovative way.
Societal considerations WP6 EA4	Students are not fully aware of the societal impact of engineering situations their design may lead to.	Students have very limited awareness of the societal situations their design may lead to.	Some awareness but no clear description on the societal consideration	Students demonstrate full awareness of the social implications such as acceptance and adaptation of the people using or being exposed to the design.	Students are able to analyze the impact of the social implications of their design such as acceptance and adaptation of the people using it or being exposed to it

Ethics and Standard (25 marks)

Similarity Index (Exclude self reference and biography)	Turnitin similarity index (TSI) => 40%	30% <= TSI < 40%	20 <= TSI <30%	10%<= TSI <20%	TSI < 10%.
Citation (Reference)	Reference cited were not related, too many/too little. Wrong format used.	The manuscript has several instances of improper use of citations. Contains several statements without appropriately citing.	Average quality, with a limited references. Some format were not followed	Properly cited. May have a few instances in which proper citations are missing.	Good and related references were explicitly cited. Cited references are well balanced (not too many/few). Reference list matches citations and in the correct format.

Communication (15 marks)

Writing mechanics	-incorrect usage of technical terms -listing of information without regards to structure and/or flow -structure was missing and incorrect format -major errors in spelling, grammar and punctuation	-some inaccurate usage of technical terms -contained repetitions and redundancies -structure was evident but inappropriate transitions, minor error in format -some major errors in spelling, grammar and punctuation	-technical terms are mostly accurate -contains minor repetitions and redundancies -structure is evident with some effort made in using transitions to link ideas together, minimal error in format -few errors in grammar and punctuations	-technical terms were used appropriately and accurately -clear with no repetitions and redundancies -structure was clear with appropriate transitions, correct format -few errors in spelling, grammar and punctuation	-strong grasp of technical concept -clear and concise -structure was clear, appropriate and effective to the purpose, correct format -minimal errors in spelling, grammar and punctuations
Graphical Representations **EA1**	-graphical presentation contained errors and lack a logical progression, diagrams or graphics were absent	-graphical presentation contain few errors, limited diagram or graphics	-graphical presentation contained minimal error and logically present the main idea, readable diagrams or graphics	-graphical presentation were error-free, logical presentation, readable and interesting diagrams or graphics	-graphical presentation were error-free and logically present the main idea, interesting and innovative diagrams or graphics
Content **EA1-5**	-insufficient breadth and depth to show that required topics were met	-some gaps in the coverage of required topics	-covered most required topics	-covered all required topics	-covered all required topics well with excellent breadth and depth

Sustainability (10 marks)

Environmental WP1,6 EA1,2,4	Considered any ONE of the listed environmental criteria i. Optimized usage of resources ii. Used of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any TWO of the listed environmental criteria i. Optimized usage of resources ii. Used of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any THREE of the listed environmental criteria i. Optimized usage of resources ii. Used of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any FOUR of the listed environmental criteria i. Optimized usage of resources ii. Used of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered ALL of the listed environmental criteria i. Optimized usage of resources ii. Used of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)

Sustainability (10 marks)

Social WP1,6 EA1,2,4	NONE of the listed social criteria was considered i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered any ONE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered any TWO of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered THREE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered ALL of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)

Technical investigation and analysis (10 marks)

PART B: Poster & Demo Presentation (Group)					
Marks Criteria	1 Very poor	2 Poor	3 Satisfactory	4 Good	5 Excellent
Technical investigation and analysis WP1-7 EA1-2,4	Not competent at all in the technical investigations of the proposed design (No calculation, simulation and justification were given at all in the technical analysis of the proposed design)	Demonstrated poor competency in the technical investigations of the proposed design (Insufficient calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated some degree of competency in the technical investigations of the proposed design (Comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated high competency in the technical investigations of the proposed design (Highly comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated extremely high competency in the technical investigations of the proposed design (Extremely comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)
Use modern tools WP1 EA1	Modern tools and basic engineering principles were not considered at all in the technical analysis of the proposed design	Poor usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated satisfactory usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated highly competent usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated extremely competent usage of modern tools and basic engineering principles in the technical analysis of the proposed design

Ethics & Standard (10 marks)

Identify relevant standard testing procedures WP1,5,6 EA4	Very poor consideration given to relevant standard testing procedures in the design.	Group is aware of related testing procedures but limited consideration were given in its execution in the design.	Some consideration given to the relevant standard testing procedures	Ample considerations were given to related testing procedures.	Outstanding consideration given to relevant standard testing procedures which were executed in the design.
Safety and health considerations WP6 EA4	Total ignorance of safety related issues. Obvious safety problems detected in the proposed design.	The design appears to be potentially safe but the safety awareness is poorly articulated in the report; some attention seems to be given to safety.	Group recognizes and satisfactorily includes relevant safety related design issues in the proposed design.	Group usually recognizes and adequately includes relevant safety related design issues in the proposed design.	Group almost always recognizes, anticipates, and includes relevant safety related design issues. The safety aspect is included in the design in an innovative way.
Societal considerations WP6 EA4	Students are not fully aware of the societal impact of engineering situations their design may lead to.	Students have very limited awareness of the societal situations their design may lead to.	Some awareness but no clear description on the societal consideration	Students demonstrate full awareness of the social implications such as acceptance and adaptation of the people using or being exposed to the design.	Students are able to analyze the impact of the social implications of their design such as acceptance and adaptation of the people using it or being exposed to it

Communication (15 marks)

Oral Performance	-presentation was not understood by audience -lot of distracting gestures (tapping a pen, wringing hands, waving arms, clenching fists, etc), no audience eye contact, -unable to handle most Q&A	-difficult to follow the presentation -a few distracting gestures, limited eye contact with audience -able to handle some Q&A	-able to follow presentation but heavily scripted -slight tendency to distracting gestures, some eye contact with audience -able to handle most Q&A	-able to follow the presentation which was delivered well and smoothly -Appropriate gesture, a few eye contact with audience -able to handle all Q&A well	-presentation was interesting, well delivered with enthusiasm -meaningful gestures, eye contact with audience -able to handle all Q&A well
Graphical Representations **EA1**	-graphical presentation contained errors and lack a logical progression, diagrams or graphics were absent	-graphical presentation contain few errors, limited diagram or graphics	-graphical presentation contained minimal error and logically present the main idea, readable diagrams or graphics	-graphical presentation were error-free, logical presentation, readable and interesting diagrams or graphics	-graphical presentation were error-free and logically present the main idea, interesting and innovative diagrams or graphics
Content **EA1-5**	-insufficient breadth and depth to show that required topics were met	-some gaps in the coverage of required topics	-covered most required topics	-covered all required topics	-covered all required topics well with excellent breadth and depth

Sustainability (10 marks)

Environmental WP1,6 EA1,2,4	Considered any ONE of the listed environmental criteria i. Optimized usage of resources ii. Use of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any TWO of the listed environmental criteria i. Optimized usage of resources ii. Use of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any THREE of the listed environmental criteria i. Optimized usage of resources ii. Use of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered any FOUR of the listed environmental criteria i. Optimized usage of resources ii. Use of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)	Considered ALL of the listed environmental criteria i. Optimized usage of resources ii. Use of recovered and renewable resources iii. Protected ecosystem iv. Minimise or eliminate emission of hazardous substances. v. Incorporated life cycle approach)

Sustainability (10 marks)

Social WP1,6 EA1,2,4	NONE of the listed social criteria was considered i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being Requests iv. Incorporated life cycle approach)	Considered any ONE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being Requests iv. Incorporated life cycle approach)	Considered any TWO of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being Requests iv. Incorporated life cycle approach)	Considered THREE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being Requests iv. Incorporated life cycle approach)	Considered ALL of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being Requests iv. Incorporated life cycle approach)

Supervisor's evaluation: Team work (20 marks)

PART A: Weekly Meeting (Individual)						
Marks / Criteria	1 Very poor	2 Poor	3 Satisfactory	4 Good	5 Excellent	
Delegation and fulfillment of responsibilities	Major inequities in delegation of responsibilities. Group had more than two freeloaders who failed to meet their responsibilities.	Some major inequities in the delegation of responsibilities. Group had one freeloader who fails to meet their responsibilities.	Some minor inequities in the delegation of responsibilities. Some members contributed more heavily than others but all members met their responsibilities.	Responsibilities were delegated well. Each member contributed to the project.	Responsibilities delegated fairly. Each member contributed in a valuable way to the project.	
Focus and punctuality	Members often missed meetings and deadlines	Members missed some meetings, and deadlines for deliverables were met sometimes	Members regularly attended meetings with only a few absences, and deadlines for deliverables were met.	Most Members regularly attended meeting, and deadlines for deliverables were met.	All members always attended meetings and met deadlines for deliverables.	

Supervisor's evaluation: Team work (20 marks)

Team communication	**Team did not collaborate or communicate well. Some members would work independently, without regard to objectives or priorities. A lack of respect and regard was frequently noted.**	**Team collaborated and communicated in some ways. A lack of respect and regards was sometimes noted.**	**Team worked well together most of the time, with only a few occurrences of communication breakdown or failure to collaborate when appropriate. Members were mostly respectful of each other.**	**Team worked well together to achieve objectives. Members interacted with each other and learned from each other. Members showed mutual respect and collaboration.**	**Team worked well together to achieve objectives. Members enjoyed interacting with each other and learned from each other. All data sources indicated a high level of mutual respect and collaboration.**
Peer review **Supervisor gives marks based on rank given by students among themselves (1st - 3rd)**	Lowest rank (with the highest cumulative point		Middle rank	Highest rank (with the lowest cumulative point)	

Supervisor's evaluation: Technical investigation and analysis (10 marks)

PART B: Final Report (Group)					
Marks **Criteria**	1 Very poor	2 Poor	3 Satisfactory	4 Good	5 Excellent
Technical investigation and analysis **WP1-7** **EA1-2,4**	Not competent at all in the technical investigations of the proposed design (No calculation, simulation and justification were given at all in the technical analysis of the proposed design)	Demonstrated poor competency in the technical investigations of the proposed design (Insufficient calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated some degree of competency in the technical investigations of the proposed design (Comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated high competency in the technical investigations of the proposed design (Highly comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)	Demonstrated extremely high competency in the technical investigations of the proposed design (Extremely comprehensive calculation, simulation and justification were given in the technical analysis of the proposed design)
Use modern tools **WP1** **EA1**	Modern tools and basic engineering principles were not considered at all in the technical analysis of the proposed design	Poor usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated satisfactory usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated highly competent usage of modern tools and basic engineering principles in the technical analysis of the proposed design	Demonstrated extremely competent usage of modern tools and basic engineering principles in the technical analysis of the proposed design

Supervisor's evaluation: Project management and economic feasibility (20 marks)

Risk management **EA1,2,4**	**Addresses only surface-level or obvious risks**	**Minimally explores options to mitigate risks; Only explores options for the most basic risks**	**Realistically estimates the probability and severity of all risks identified**	**Selects mostly ppropriate mitigating actions; Somewhat considers the prior risk identification and assessment**	**Realistically assesses all risks, considering the probability of occurrence and severity of consequences**
Schedule	Fails to include important details or to reflect the goals of project in the schedule.	Developed a schedule that omitted significant project activities/tasks	Developed a comprehensive schedule of project activities/tasks but identified unrealistic due dates	Developed a comprehensive schedule of project activities/tasks with realistic due dates	Developed an outstanding schedule that facilitates implementation and takes into account the goals of the project with realistic due dates.
Resources **EA1,2**	Insufficient resources identified for the project	Identified some resources needed for the project	Identified most resources needed for the project	Identified all resources needed for the project	Identified and managed all resources within identified constraints
Budget/cost	Missing/ incomplete/over budget	Demonstrated minimal ability to reate or adhere to a budget.	Demonstrated some ability to create and/or adhere to a budget. Budget covers most applicable areas.	Demonstrated an ability to create and/or adhere to a budget. Budget covers all applicable areas of project.	Demonstrated a skillful ability to create and/or adhere to a budget. Budget covers all applicable areas, with room for contingencies.

Supervisor's evaluation: Ethics and standard (25 marks)

Identify relevant standard testing proceedures WP1,5,6 EA4	Very poor consideration given to relevant standard testing proceedures in the design.	Group is aware of related testing proceedures but limited consideration were given in its execution in the design.	Some consideration given to the relevant standard testing procedures	Ample considerations were given to related testing proceedures.	Outstanding consideration given to relevant standard testing proceedures which were executed in the design.
Safety and health considerations WP6 EA4	Total ignorance of safety related issues. Obvious safety problems detected in the proposed design.	The design appears to be potentially safe but the safety awareness is poorly articulated in the report; some attention seems to be given to safety.	Group recognizes and satisfactorarily includes relevant safety related design issues in the proposed design.	Group usually recognizes and adequately includes relevant safety related design issues in the proposed design.	Group almost always recognizes, anticipates, and includes relevant safety related design issues. The safety aspect is included in the design in an innovative way.

Supervisor's evaluation: Ethics and standard (25 marks)

Societal considerations WP6 EA4	Students are not fully aware of the societal impact of engineering situations their design may lead to.	Students have very limited awareness of the societal situations their design may lead to.	Some awareness but no clear description on the societal consideration	Students demonstrate full awareness of the social implications such as acceptance and adaptation of the people using or being exposed to the design.	Students are able to analyze the impact of the social implications of their design such as acceptance and adaptation of the people using it or being exposed to it
Similarity Index (Exclude self reference and biography)	Turnitin similarity index (TSI) => 40%	30% <= TSI < 40%	20 <= TSI <30%	10%<= TSI <20%	TSI < 10%.
Citation (Reference)	Reference cited were not related, too many/too little. Wrong format used.	The manuscript has several instances of improper use of citations. Contains several statements without appropriately citing.	Average quality, with a limited references. Some format were not followed	Properly cited. May have a few instances in which proper citations are missing.	Good and related references were explicitly cited. Cited references are well balanced (not too many/few). Reference list matches citations and in the correct format.

Supervisor's evaluation: Communication (10 marks)

Writing mechanics	-incorrect usage of technical terms -listing of information without regards to structure and/or flow -structure was missing and incorrect format -major errors in spelling, grammar and punctuation	-some inaccurate usage of technical terms -contained repetitions and redundancies -structure was evident but inappropriate transitions, minor error in format -some major errors in spelling, grammar and punctuation	-technical terms are mostly accurate -contains minor repetitions and redundancies -structure is evident with some effort made in using transitions to link ideas together, minimal error in format -few errors in grammar and punctuations	-technical terms were used appropriately and accurately -clear with no repetitions and redundancies -structure was clear with appropriate transitions, correct format -few errors in spelling, grammar and punctuation	-strong grasp of technical concept -clear and concise -structure was clear, appropriate and effective to the purpose, correct format -minimal errors in spelling, grammar and punctuations
Content EA1-5	-insufficient breadth and depth to show that required topics were met	-some gaps in the coverage of required topics	-covered most required topics	-covered all required topics	-covered all required topics well with excellent breadth and depth

Supervisor's evaluation: Sustainability (10 marks)

Environmental WP1,6 EA1,2,4	Considered any ONE of the listed environmental criteria	Considered any TWO of the listed environmental criteria	Considered any THREE of the listed environmental criteria	Considered any FOUR of the listed environmental criteria	Considered ALL of the listed environmental criteria
	i. Optimized usage of resources	i. Optimized usage of resources	i. Optimized usage of resources	i. Optimized usage of resources	i. Optimized usage of resources
	ii. Used of recovered and renewable resources	ii. Used of recovered and renewable resources	ii. Used of recovered and renewable resources	ii. Used of recovered and renewable resources	ii. Used of recovered and renewable resources
	iii. Protected ecosystem	iii. Protected ecosystem	iii. Protected ecosystem	iii. Protected ecosystem	iii. Protected ecosystem
	iv. Minimise or eliminate emission of hazardous substances.	iv. Minimise or eliminate emission of hazardous substances.	iv. Minimise or eliminate emission of hazardous substances.	iv. Minimise or eliminate emission of hazardous substances.	iv. Minimise or eliminate emission of hazardous substances.
	v. Incorporated life cycle approach)	v. Incorporated life cycle approach)	v. Incorporated life cycle approach)	v. Incorporated life cycle approach)	v. Incorporated life cycle approach)

Supervisor's evaluation: Sustainability (10 marks)

Social WP1,6 EA1,2,4	NONE of the listed social criteria was considered i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered any ONE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered any TWO of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered THREE of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)	Considered ALL of the listed social criteria i. Addressed community and stakeholder requests ii. Considered local circumstances and cultures iii. Protected human health and well-being requests iv. Incorporated life cycle approach)

Definition of Complex Problem Solving

No.	Attribute	**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.
WP2	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.
WP3	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.
WP4	Familiarity of issues	Involve infrequently encountered issues.
WP5	Extent of applicable codes	Are outside problems 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.
WP7	Interdependence	Are high level problems including many component parts or sub-problems.

Definition of Complex Engineering Activities

No.	Attribute	**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).
EA2	Level of interactions	Require resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues.
EA3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel
EA4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.
EA5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.

Knowledge Profile

No.	Knowledge Profile
WK3	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.
WK5	Knowledge that supports **engineering design** in a practice area.
WK6	Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline.
WK8	Engagement with selected knowledge in the **research literature** of the discipline.

THANKS A MILLION