WORKSHOP ON THE IMPLEMENTATION OF COMPLEX ENGINEERING PROBLEM SOLVING (WP) AND COMPLEX ENGINEERING ACTIVITIES (EA)

Board of Accreditation for Engineering and Technical Education, Institution of Engineers Bangladesh, 18-19 June 2019

SITI HAWA HAMZAH
PhD, P. Eng, FIEM, Hon MAFEO ASEAN Engr, MRM, PSWM
ASSOCIATE DIRECTOR (CIVIL ENGINEERING) BEM
sitihawabthamzah@gmail.com
LIEW CHIA PAO
P. Eng, MIEM
ASSOCIATE DIRECTOR (ELECTRONIC ENGINEERING) BEM
PRINCIPAL LECTURER, TUNKU ABDUL RAHMAN UNIVERSITY COLLEGE, MALAYSIA
liewcp@tarc.edu.my

Time	Workshop Schedule
9:30 – 9:45	**Introduction and Outcomes of the Workshop**
9:45 – 10:45	**Overview of Graduate Attributes and Knowledge Profile**
10:45 – 11:00	Tea Break
11:00 – 12:00	**Group Discussion**
12:00 – 13:00	**Overview of Complex Engineering Problem Solving and Complex Engineering Activities**
13:00 – 14:00	Lunch
14:00 – 15:30	**Group Discussion**
15:30 – 15:45	Break
15:45 – 16:45	**Group Presentation**
16:45 – 17:00	**Closure and Reflection**

LEARNING OUTCOMES

At the end of the presentation, participants are able to;

1. Have the insight into the requirements of WP and EA defined by the IEA;
2. Map the courses of a programme to fulfil the requirements of WA defined by the IEA; and
3. Design a course/courses that address WP and EA.
4. Contribute to CQI process in the effort of improving learning process and achievement of the learning outcomes of the students

TERMINOLOGIES

WP (P)	• Complex Problem Solving
EA (A)	• Complex Engineering Activities
WA=PO	• Graduate Attributes ((a)-(l))
WK (K)	• Knowledge Profile

Defining standards of education and professional competence. (http://www.ieagreements.org/)

Version 1: June 2005

Version 2: June 2009

VERSION 3: JUNE 2013

International agreements GOVERN the recognition of engineering educational qualifications and professional competence, thus establishing and enforcing internationally bench-marked standards.

EDUCATION ACCORDS

- WA (20 MEMBER COUNTRIES) 1989
- SA (11 MEMBER COUNTRIES) 2001
- DA (9 MEMBER COUNTRIES) 2002

AGREEMENTS

- APEC
- IPEA
- IETA
- AIET

WA	SA	DA
Signed in 1989, the Washington Accord, is a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications within their jurisdictions who have chosen to work collectively to **assist the mobility of professional engineers.** • The Washington Accord is specifically focused on academic programmes which deal with the practice of **engineering at the professional level.**	• The Sydney Accord is specifically focused on academic programmes dealing with **engineering technology.** • The Accord acknowledges that accreditation of these academic programmes is a key foundation for the practice of engineering technology in each of the countries or territories covered by the Accord. • It recognises the **importance of the roles engineering technologists as part of a wider engineering team.**	• The Dublin Accord is specifically focused on the mutual recognition of academic programmes/ qualifications that underpin the **educational base for Engineering Technicians.** • The Accord acknowledges that the educational base is a key foundation for practice as an engineering technician, in each of the countries or territories covered by the Accord. • It recognises the **importance of the roles engineering technicians play as part of a wider engineering team.**

WA Member Countries

1. Australia - (EA) (1989)
2. Canada – (EC) (1989)
3. China - (CAST) (2016)
4. Chinese Taipei - (IEET) (2007)
5. Hong Kong China - (HKIE) (1995)
6. India - (NBA) (2014)
7. Ireland - (EI) (1989)
8. Japan - (JABEE) (2005)
9. Korea - (ABEEK) (2007)
10. Malaysia - (BEM) (2009)
11. New Zealand - (IPENZ) (1989)
12. Russia - (AEER) (2012)
13. Singapore - (IES) (2006)
14. South Africa - (ECSA) (1999)
15. Sri Lanka - (IESL) (2014)
16. Turkey - (MÜDEK) (2011)
17. United States - (ABET) (1989)
18. United Kingdom - (ECUK) (1989)
19. Pakistan - (PEC) (2017)
20. Peru – (ICACIT) (2018)

PROVISIONAL MEMBERS

1. Bangladesh - (IEB)
2. Costa Rica - (CFIA)
3. Mexico - (CACEI)
4. Philippines - (PTC)
5. Chile – (ACREDITA CI)

SA Member Countries

1. Australia - (EA) (2001)
2. Canada - (CCTT) (2001)
3. Chinese Taipei - (IEET) (2014)
4. Hong Kong China - (HKIE) (2001)
5. Ireland - (EI) (2001)
6. Korea - (ABEEK) (2013)
7. New Zealand - (IPENZ) (2001)
8. South Africa - (ECSA) (2001)
9. United Kingdom - (ECUK) (2001)
10. United States - (ABET) (2009)
11. **MALAYSIA – (BEM) (2018)**

PROVISIONAL MEMBERS

1. Peru - (ICACIT)
2. Sri Lanka – (IESL)

DA Member Countries

1. Australia - (EA) (2013)
2. Canada - (CCTT) (2002)
3. Ireland - (EI) (2002)
4. New Zealand - (IPENZ) (2013)
5. Korea - (ABEEK) (2013)
6. South Africa - (ECSA) (2002)
7. United Kingdom - (ECUK) (2002)
8. United States - (ABET) (2013)
9. **MALAYSIA – (BEM) (2018)**

PROVISIONAL MEMBERS

NONE to date

IPEA MEMBERS

1. Australia - Engineers Australia (EA) (1997)
2. Canada - Engineers Canada (EC) (1997)
3. Chinese Taipei - Chinese Institute of Engineers (CIE) (2009)
4. Ireland - Engineers Ireland (EI) (1997)
5. Hong Kong China - Hong Kong Institution of Engineers (HKIE) (1997)
6. India - Institution of Engineers India (IEI) (2009)
7. Japan - Institution of Professional Engineers Japan (IPEJ) (1999)
8. Korea - Korean Professional Engineers Association (KPEA) (2000)
9. Malaysia - Institution of Engineers Malaysia (IEM) (1999)
10. New Zealand - Engineering New Zealand (EngNZ) (1997)
11. Singapore - Institution of Engineers Singapore (IES) (2007)
12. South Africa - Engineering Council South Africa (ECSA) (2007)
13. Sri Lanka - Institution of Engineers Sri Lanka (IESL) (2007)
14. United Kingdom - Engineering Council United Kingdom (ECUK) (1997)
15. United States - National Council of Examiners for Engineering and Surveying (NCEES) (1997)
16. Pakistan - Pakistan Engineering Council (PEC) (2018)

PROVISIONAL MEMBERS

1. Bangladesh - Bangladesh Professional Engineers Registration Board (BPERB)
2. Russia - Association for Engineering Education of Russia (AEER)
3. The Netherlands - Royal Netherlands Society of Engineers (KIVI)

IETA MEMBERS

1. Canada - Canadian Council of Technicians and Technologists (CCTT) (2001)
2. Hong Kong China - Hong Kong Institution of Engineers (HKIE) (2001)
3. Ireland - Engineers Ireland (EI) (2001)
4. New Zealand - Engineering New Zealand (EngNZ) (2001)
5. South Africa - Engineering Council South Africa (ECSA) (2001)
6. United Kingdom - Engineering Council United Kingdom (ECUK) (2001)
7. Australia - Engineers Australia (EA) (2018)

PROVISIONAL MEMBERS

NONE to date

AIET MEMBERS

1. Australia - Engineers Australia (EA) (2016)
2. Canada - Canadian Council of Technicians and Technologists (CCTT) (2016)
3. Ireland - Engineers Ireland (EI) (2016)
4. New Zealand - Engineering New Zealand (EngNZ) (2016)
5. South Africa - Engineering Council South Africa (ECSA) (2016)
6. United Kingdom - Engineering Council United Kingdom (ECUK) (2016)

PROVISIONAL MEMBERS

NONE to date

APEC ENGINEER MEMBER ECONOMIES

1. Australia - Engineers Australia (EA) (2000)
2. Canada - Engineers Canada (EC) (2000)
3. Chinese Taipei - Chinese Institute of Engineers (CIE) (2005)
4. Hong Kong China - Hong Kong Institution of Engineers (HKIE) (2000)
5. Indonesia – Persatuan Insinyur Indonesia (PII) (2001)
6. Japan - Institution of Professional Engineers Japan (IPEJ) (2000)
7. Korea - Korean Professional Engineers Association (KPEA) (2000)
8. Malaysia - Institution of Engineers Malaysia (IEM) (2000)
9. New Zealand - Engineering New Zealand (EngNZ) (2000)
10. Philippines - Philippine Technological Council (PTC) (2003)
11. Russia – Association for Engineering Education of Russia (AEER) (2010)
12. Singapore - Institution of Engineers Singapore (IES) (2005)
13. Thailand – Council of Engineers Thailand (COE) (2003)
14. United States – National Council of Examiners for Engineering and Surveying (NCEES) (2001)
15. Peru – Peruvian Engineers Association (PEA/CIP) (2018)

WA

PROFESSIONAL ENGINEERING GRADUATES are expected to work with Complex Engineering Problems

Complex Engineering Problems (Engineer)
Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach

Complex Engineering Activities or Projects

SA

TECHNOLOGIST GRADUATES to work with Broadly Defined Engineering Problems

Broadly Defined Problems (Technologist)
Requires knowledge of principles and applied procedures or methodologies

Broadly Defined Engineering Activities or Projects

DA

TECHNICIAN GRADUATES to work with Well-Defined Engineering Problems

Well-defined Problems (Technician)
Can be solved using limited theoretical knowledge, but normally requires extensive practical knowledge

Well-defined Engineering Activities or Projects

WA = Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach

- WK1- natural sciences
- WK2 – mathematics
- WK3 – engineering fundamentals
- WK4 – specialist knowledge
- WK5 – engineering design
- WK6 – engineering practice
- WK7 – comprehension
- WK8 – research literature

SA = Requires knowledge of principles and applied procedures or methodologies

- SK1- natural sciences
- SK2 – mathematics
- SK3 – engineering fundamentals
- SK4 – specialist knowledge
- SK5 – engineering design
- SK6 – engineering technologies
- SK7 – comprehension
- SK8 – technological literature

DA = Can be solved using limited theoretical knowledge, but normally requires extensive practical knowledge

- DK1- natural sciences
- DK2 – mathematics
- DK3 – engineering fundamentals
- DK4 – specialist knowledge
- DK5 – engineering design
- DK6 – practical engineering knowledge
- DK7 – comprehension

GRADUATE ATTRIBUTES (Keywords)	PROFESSIONAL ENGINEERING GRADUATES - Complex Engineering Problems		TECHNOLOGIST GRADUATES - Broadly Defined Engineering Problems		TECHNICIAN GRADUATES - Well-Defined Engineering Problems	
	WA-WK's	WP/EA	SA-SK's	BD/EA	DA-DK's	WD/EA
1. Engineering Knowledge	WK1-WK4	WP	SK1-SK4	BD	DK1-DK4	WD
2. Problem Analysis	WK1-WK4	WP	SK1-SK4	BD	DK1-DK4	WD
3. Design/Development of Solutions	WK5	WP	SK5	BD	DK5	WD
4. Investigation	WK8	WP	SK8	BD	-	WD
5. Modern Tool Usage	WK6	WP	SK6	BD	DK6	WD
6. The Engineer and Society	WK7	WP	SK7	BD	DK7	WD
7. Environment and Sustainability	WK7	WP	SK7	BD	DK7	WD
8. Ethics	WK7		SK7		DK7	
9. Individual and Team work						
10. Communication		EA		TA		NA
11. Project Management and Finance						
12. Life Long Learning						

Assessments Provide Adequate Feedback To The Programme To Identify Strengths And Weaknesses For CQI

12 PO Trays

- Engineering Knowledge
- Problem Analysis
- Design/ Development of Solutions
- Investigation
- Modern Tool Usage
- The Engineer and Society
- Environment and Sustainability
- Ethics
- Individual and Team work
- Communication
- Project Management and Finance
- Lifelong learning

PO ASSESSMENT MODELS

1
- **Accumulated model** – **ALL** courses contributing to the PO measurements

2
- **Dominating model** – **SELECTED** courses contributing to the PO measurements, normally accounted in several CORE courses.

3
- **Culminating model** – **SELECTED FEW** usually between 3-5 courses contributing to the PO measurements, normally conducted during the final year of study.

WA Graduate Attributes

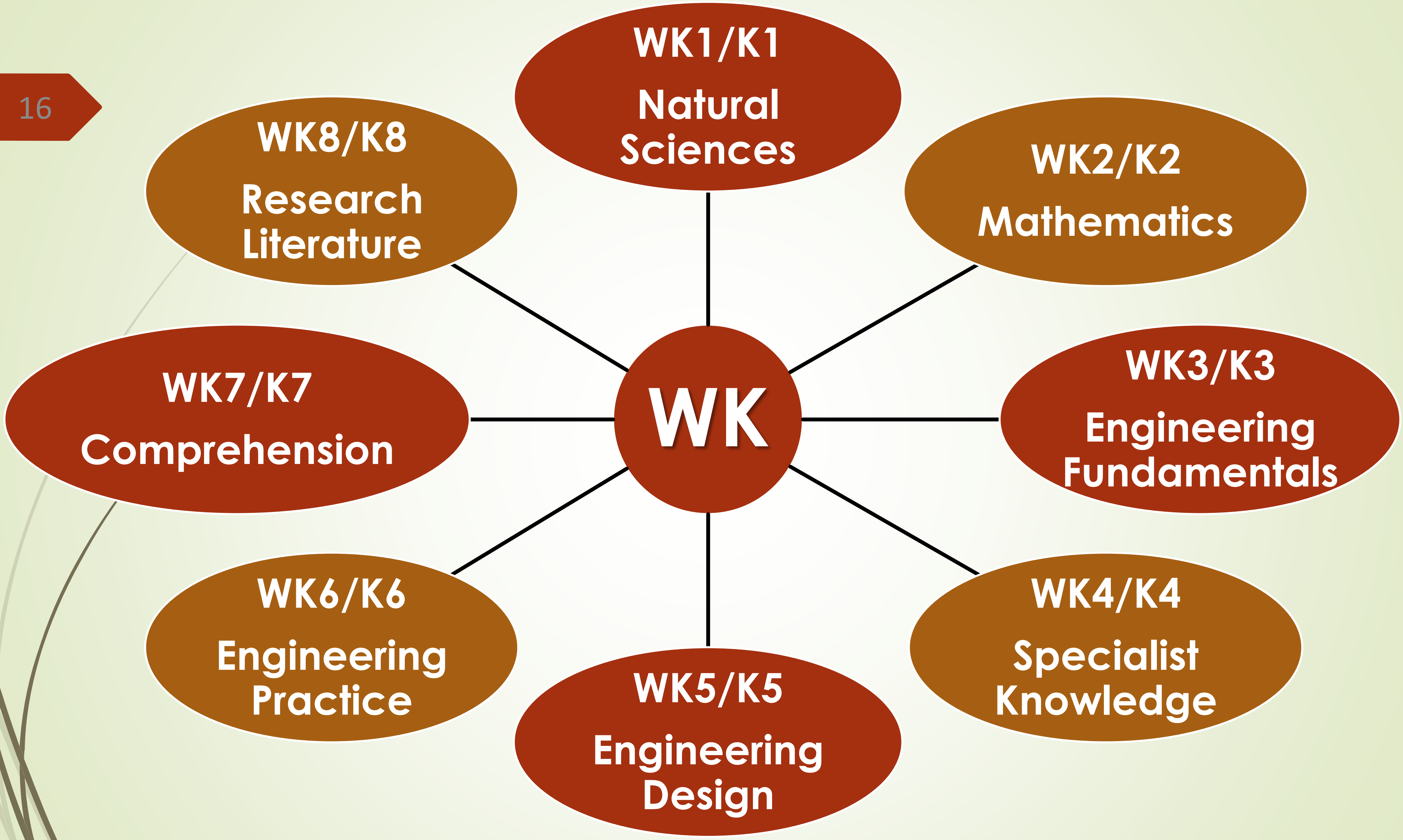
WA1 - Engineering Knowledge	Apply mathematics, natural science, engineering fundamentals and engineering specialization to the solution of **complex engineering problems** **(WK1, WK2, WK3, WK4)**
WA2 - Problem Analysis	Identify, formulate, research literature & analyse **complex engineering problems** using first principles of mathematics, natural sciences and engineering sciences **(WK1, WK2, WK3, WK4)**
WA3 -Design/ Development of Solutions	Design solutions for **complex engineering problems** and design systems, components or processes with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. **(WK5)**
WA4 - Investigation	Conduct investigations of **complex problems** using research-based knowledge and research methods **(WK8)**
WA5 - Modern Tool Usage	Create, select and apply modern engineering and IT tools including prediction and modelling to **complex engineering problems** **(WK6)**
WA6 - The Engineer and Society	Apply reasoning 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)**

WA Graduate Attributes

WA7 - Environment and Sustainability	Understand and evaluate the sustainability and impact of professional engineering work in the solution of **complex engineering problems.** **(WK7)**
WA8 - Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. **(WK7)**
WA9 - Individual and Team work	Function effectively as an individual, member or leader in diverse teams and in multi-disciplinary settings
WA10 - Communication	Communicate effectively on **complex engineering activities** with the engineering community and with society able to comprehend, write, present, give and receive instructions
WA11 - Project Management and Finance	Demonstrate knowledge and understanding of engineering management principles and economic decision-making, apply to own work, as a member and leader in a team, manage projects and in multidisciplinary environments
WA12 - Lifelong learning	Recognize the need, prepare and engage in independent and life-long learning

Mar2019BAETE Graduate Attributes (Section 4.8)	
(a) - Engineering Knowledge	Apply *knowledge of* mathematics, natural science, engineering fundamentals and *an* engineering specialization *as specified in* **K1 to K4** *respectively* to the solution of **complex engineering problems**
(b) - Problem Analysis	Identify, formulate, research literature & analyse **complex engineering problems** *reaching substantiated conclusions* using first principles of mathematics, natural sciences and engineering sciences **(K1, K2, K3, K4)**
(c) -Design/ Development of Solutions	Design solutions for **complex engineering problems** and design systems, components or processes with appropriate consideration for public health and safety, cultural, societal, and environmental considerations **(K5)**
(d) – Investigation	Conduct investigations of **complex problems** using research-based knowledge **(K8)** and research methods *including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions*
(e) - 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* **(K6)**
(f) - 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 (K7)**

Mar2019BAETE Graduate Attributes (Section 4.8)	
(g) - Environment and Sustainability	Understand and evaluate the sustainability and impact of professional engineering work in the solution of **complex engineering problems** *in societal and environmental contexts*. **(K7)**
(h) – Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. **(K7)**
(i) - Individual and Team work	Function effectively as an individual, *and as a* member or leader in diverse teams and in multi-disciplinary settings
(j) - 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
(k) - 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 and in multidisciplinary environments
(l) - Lifelong learning	Recognize the need *for*, *and have the preparation and ability to* engage in independent and life-long learning *in the broadest context of technological change*.



BAETE Manual 2019, 2nd ed, Table 4.1

	BAETE MANUAL 2019, 2nd ed. (TABLE 4.1) - KNOWLEDGE PROFILE	
K1	Natural sciences	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
K2	Mathematics	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
K3	Engineering fundamentals	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
K4	Specialist Knowledge	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.
K5	Engineering Design	Knowledge that supports engineering design in a practice area.
K6	Engineering Practice	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
K7	Comprehension	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.
K8	Research literature	Engagement with selected knowledge in the research literature of the discipline.

WK & PO RELATIONSHIP

WK1	Theory-based natural sciences	PO1 - ENGINEERING KNOWLEDGE
WK2	Conceptually-based mathematics	
WK3	Theory-based engineering fundamentals	PO2 - PROBLEM ANALYSIS
WK4	Forefront specialist knowledge for practice	
WK5	Engineering design	PO3 - DESIGN
WK6	Engineering practice (technology)	PO5 - MODERN TOOLS
WK7	Comprehension of engineering in society	PO6 - ENGINEERS & SOCIETY PO7 - ENVIRONMENT & SUSTAINABILITY PO8 - ETHICS
WK8	Research literature	PO4 - INVESTIGATION

PO1 - ENGINEERING KNOWLEDGE
PO2 - PROBLEM ANALYSIS
PO3 - DESIGN
PO4 - INVESTIGATION
PO5 - MODERN TOOLS

Analysis of problems & Synthesis of solutions

PO6 - ENGINEERS & SOCIETY
PO7 - ENVIRONMENT & SUSTAINABILITY
PO8 - ETHICS

RESPONSIBILITIES

PO9 - TEAMWORK
PO10 - COMMUNICATION
PO11 - PROJECT MANAGEMENT & FINANCE
PO12 - LIFELONG LEARNING

Required in workplace

WK / Knowledge Profile - CHARACTERISTIC		
WK1	Natural Sciences	A systematic, theory-based understanding of the **natural sciences** applicable to the discipline
WK2	Mathematics	Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline
WK3	Engineering fundamentals	A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline
WK4	Specialist knowledge	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	Engineering design	Knowledge that supports **engineering design** in a practice area
WK6	Engineering practice	Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline
WK7	Comprehension	**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
WK8	Research literature	Engagement with selected knowledge in the **research literature** of the discipline

COMPLEX PROBLEMS have characteristic of WP1 and some or all of WP2 to WP7 (EAC Manual 2017, B-5)

POs	WK	WP
PO1 – EK	WK1-WK4	X
PO2 – PA	WK1-WK4	X
PO3 – Design	WK5	X
PO4 – I	WK8	X
PO5 – MT	WK6	X
PO6 – ES	WK7	X
PO7 – EvS	WK7	X

WP / Complex Problems - CHARACTERISTIC		
WP1	Depth of Knowledge	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	Conflicting requirement	wide-ranging or conflicting technical, engineering and other issues
WP3	Depth of analysis	no obvious solution and require abstract thinking, originality in analysis to formulate suitable models
WP4	Familiarity of issues	infrequently encountered issues
WP5	Extent of applicable codes	outside problems encompassed by standards and codes of practice for professional engineering
WP6	Extent of stakeholder	diverse groups of stakeholders with widely varying needs
WP7	Interdepen-dence	high level problems including many component parts or sub-problems

7 POs ~ WP

BREAK TIME

Kul Sharif Mosque (White Mosque) Kazan Kremlin, Russia, 16th century (rebuilt 1996-2005)

Group Discussion

1. Can we address all WK1- WK8 in 1 course?
2. Provide TWO (2) examples on how to assess WK5 - WK8.

COMPLEX ENGINEERING PROBLEMS - (WP1/P1 & some OR ALL of WP2/P2 - WP7/P7)

WP1/P1
Depth of knowledge required

WP2/P2
Range of conflicting requirements

WP3/P3
Depth of analysis required

WP4/P4
Familiarity of issues

WP5/P5
Extent of applicable codes

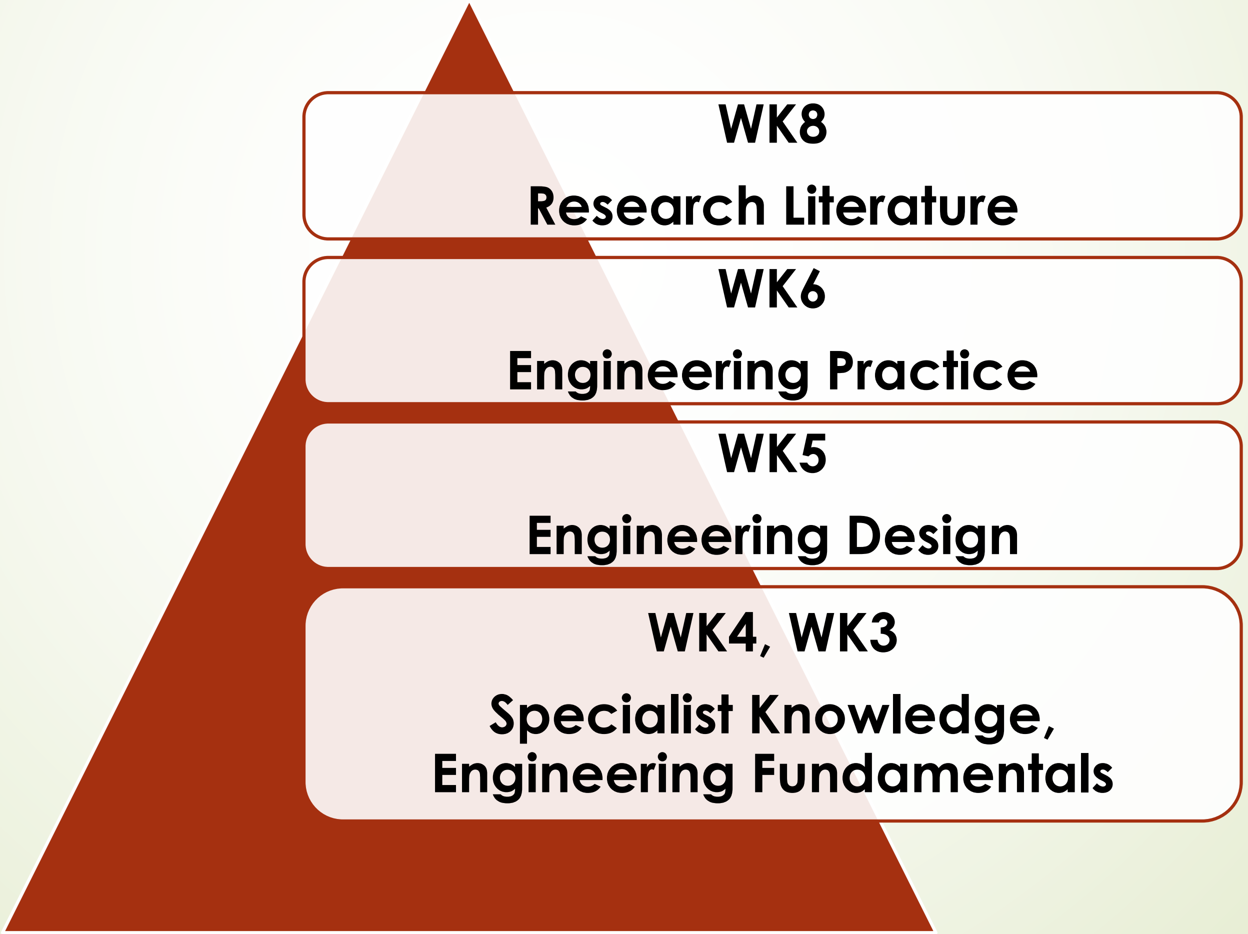
WP6/P6
Extent of stakeholder involvement and level of conflicting requirements

WP7/P7
Interdependence

KEYWORD	BAETE MANUAL 2019, 2nd ed. (TABLE 4.2) – COMPLEX ENGINEERING PROBLEMS (P1-P7) CHARACTERISTICS
Depth of knowledge required	**P1** cannot be resolved without **in-depth engineering knowledge** at the level of one or more of **K3, K4, K5, K6 or K8** which allows a fundamental based, first principles analytical approach
Range of conflicting requirements	**P2** involve **wide-ranging or conflicting** technical, engineering and other issues
Depth of analysis required	**P3** have **no obvious solution** and require abstract thinking, originality in analysis to formulate suitable
Familiarity of issues	**P4** involve **infrequently** encountered issues
Extent of applicable codes	**P5** are **outside problems** encompassed by **standards and codes of practice** for professional engineering
Extent of stakeholder involvement & conflicting requirements	**P6** **diverse** groups of stakeholders with **widely varying needs**
Interdependence	**P7** **high level problems** including many component **parts or sub-problems**

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 fundamentals-based, first principles analytical approach.**

MUST HAVE



WP1

In–Depth Knowledge = knowledge gained from courses/ learning activities beyond the introductory instructional level

1st Principles = the fundamental concepts/ assumptions on which a theory, system, or method is based.

In engineering, 1st Principles start directly at the level of established laws of chemistry, physics and mathematics.

The required theoretical knowledge to solve problem/develop the design.

For example,

- ***Apply detailed theoretical knowledge working from 1st Principles to establish a workable mathematical or theoretical model***
- ***Apply some standard formulae or theoretical models mixed by exposure to similar problems***

WP2	**Range of conflicting requirements**	Involve wide-ranging or conflicting technical, engineering and other issues.

What constraints are placed to resolve the problem?

What conflicting demands in the developing a design?

How the constraints were 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 have implied or only referenced to them loosely.

WP3	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.

What are guidance/ constraints given to develop the solution/ design?

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 to 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.

WP4	Familiarity of issues	Involve infrequently encountered issues

To what extent is this problem routinely encountered and resolved using well-understood practices?

The problem is a:

- *New problem* not previously or only rarely encountered.
- *Familiar problem* with either:
  - Clearly defined methods and/or practices used to resolve.
  - Some (or many) unique issues that made resolution difficulty level increases.

WP5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering

How do existing standards, codes dictate the solution?

How to analyse/ investigate or develop a solution/ design by either:

- Applying engineering skill 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 practice) because the problem was so ill-defined that it did not fall within any specific standards, codes or codified engineering practices.

WP6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.

How do stakeholder interests and requirements impact on the problem?

Are there conflicting requirements? If so, how did you interact with affected stakeholders to resolve the conflicts?

- Who are your stakeholders?
- What are their interests or requirements ?
- The extent these interests or requirements conflicted and/or placed constraints on the problem
- How do you manage your stakeholders to resolve conflicts, meet their requirements or reach satisfactory compromises ?

WP7	Interdependence	Are high level problems including many component parts or sub-problems.

The problem is able to be broken down into smaller components or sub-problems, not physically but mathematically

INTERNAL AUDIT AND MODERATION

CHECKLIST

- *PROGRAMME OUTCOMES MEASURED ARE PO1 – PO7*
- *WP1 EVIDENT IN ALL PO1 – PO7*
- *CHECK FOR WP2 – WP7*
- *CHECK FOR WK3 – WK8*
- *REVIEW THE QUESTIONS CRITICALLY*
- *IDENTIFY DIFFICULTY LEVELS AND COMPLEXITY CHARACTERIS-TICS*
- *REPORT YOUR FINDINGS*

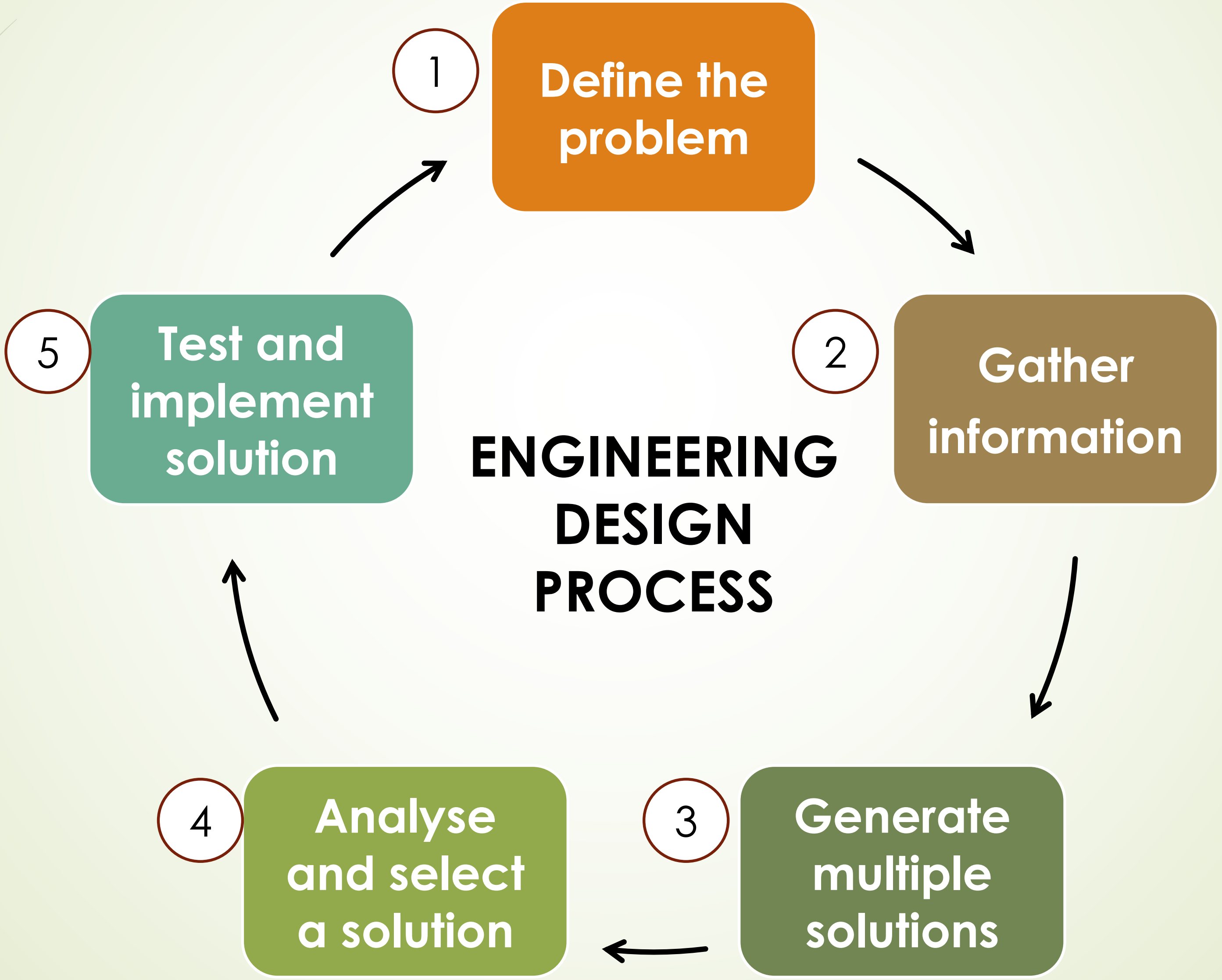
PO		X
PO1	EK	
PO2	PA	
PO3	DESIGN	
PO4	I	
PO5	MT	
PO6	ES	
PO7	EvS	

WK		X
WK1	Natural Sciences	
WK2	Mathematics	
WK3	Engineering fundamentals	
WK4	Specialist knowledge	
WK5	Engineering design	
WK6	Engineering practice	
WK7	Comprehension	
WK8	Research literature	

WP		X
WP1	Depth of Knowledge	
WP2	Conflicting requirement	
WP3	Depth of analysis	
WP4	Familiarity of issues	
WP5	Extent of applicable codes	
WP6	Extent of stakeholder	
WP7	Interdependence	

1 – A simple illustration on how design constraints can be applied

TYPICAL DESIGN PROCESS



STEP 1 - DEFINE THE PROBLEM

PROBLEM DEFINITION STATEMENT: A BETTER MOUSETRAP

Certain rodents such as the common mouse are carriers and transmitters of an often fatal virus, the hantavirus. Conventional mousetraps expose people to this virus as they handle the trap and dispose of the mouse. Design a mousetrap that allows a person to trap and dispose of a mouse without being exposed to any bacterial or viral agents being carried on the mouse.

Criteria for Success of a Better Mousetrap

WP2	Range of conflicting requirements

- The design must be low cost.
- The design should be safe, particularly with small children.
- The design should not be detrimental to the environment.
- The design should be aesthetically pleasing.
- The design should be simple to operate, with minimum human effort.
- The design must be disposable. (You don't reuse the trap.)
- The design should not cause undue pain and suffering for the mouse.

STEP 2 – GATHER INFORMATION

(Search for Information & Record the Results)

WP2	Range of conflicting requirements
WP4	Familiarity of issues
WP6	Extent of stakeholder involvement and level of conflicting requirements

- What are the existing solutions to the problem?
- What is wrong with the way the problem is currently being solved?
- What is right with the way the problem is currently being solved?
- What companies manufacture the existing solution to the problem?
- What are the economic factors governing the solution?
- How much will people pay for a solution to the problem?
- What other factors are important to the problem solution (such as safety, aesthetics, environment issues, and colour)?

Sources of information: *e-book, journal, technical handbook*
Engineer's logbook: *Record the results*

STEP 3 - GENERATE MULTIPLE SOLUTIONS

WP3	Depth of analysis

- The importance of teamwork – creative solutions to technical problems are not solved by individuals but by a team of people from different technical background bringing different perspective to the problem
- Strategies for generating creative solutions – brainstorming is a technique of generating many ideas & sketch-storming is the visual creation and recording of ideas

STEP 4 – ANALYSE AND SELECT A SOLUTION

- Analysis of design solutions – design problem is unique & requires different types of analysis
  - Functional analysis
  - Ergonomics
  - Product safety and liability
  - Economic and market analysis
  - Strength, mechanical, thermal analysis
- Decision process

WP1	Depth of knowledge
WP3	Depth of analysis
WP5	Extent of applicable codes

STEP 5 - TEST AND IMPLEMENT SOLUTION

- Prototyping
- Documenting the solution – engineering drawing, written communication, oral communication, scheduling and planning

WP1	**Depth of knowledge**
WP5	**Extent of applicable codes**

2 – For Discussion

SAFETY HELMET – is this a complex problem?

Carrying child pillion riders on motorcycles has become a norm in Malaysia. Usually the parents ferry their children to school, take them for leisure rides and many take long trip journey. In Malaysia, the motorcycle fatal crashes warrant a major concern.

The statistical data on road crashes involving motorcyclist from 2005-2007 in Malaysia shows that there were 25% of children below 16 years old rode as pillion riders that were involved in road crashes (MROADS, 2011). In 2008, according to the Malaysian Institute of Road Safety Research (MIROS, 2011), road crashes in Malaysia have killed 410 lives of children aged between one and 15 years old and another 2,797 children suffered serious and light injuries.

Affordable safety helmets for the child riders are limited. The minimum size available in the market here is 57cm in diameter, which will not fit comfortably and suitably for children of small and medium body built, who are younger than 7 years old. This results in riders riding and ignoring the safety, exposing these pillion riders to probable danger of serious head injury.

Students are now expected to design and develop an engineering solution (product) to protect the child rider’s head. It is must be affordable.

A must-have characteristic

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 fundamentals-based, first principles analytical approach.

WK1	Theory-based natural **sciences**
WK2	Conceptually-based **mathematics**
WK3	Theory-based engineering **fundamentals**
WK4	Forefront **specialist** knowledge for practice
WK5	Engineering **design**
WK6	Engineering **practice** (technology)
WK7	**Comprehension** of engineering in society
WK8	**Research** literature

A systematic theory-based formulation of engineering fundamentals required in the MECHANICAL engineering discipline.

- **Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the Mechanical engineering discipline.**
- **This can be obtained from courses that define Mechanical Engineering.**

- **Knowledge that supports engineering design in a practice area.**
- **Design methodologies, design codes, etc.**

A must-have characteristic

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WK6	Engineering **practice** (technology)
WK7	**Comprehension** of engineering in society
WK8	**Research** literature

Simulation software and equipment for the Mechanical discipline

Engagement with selected knowledge in the research literature of the Mechanical discipline

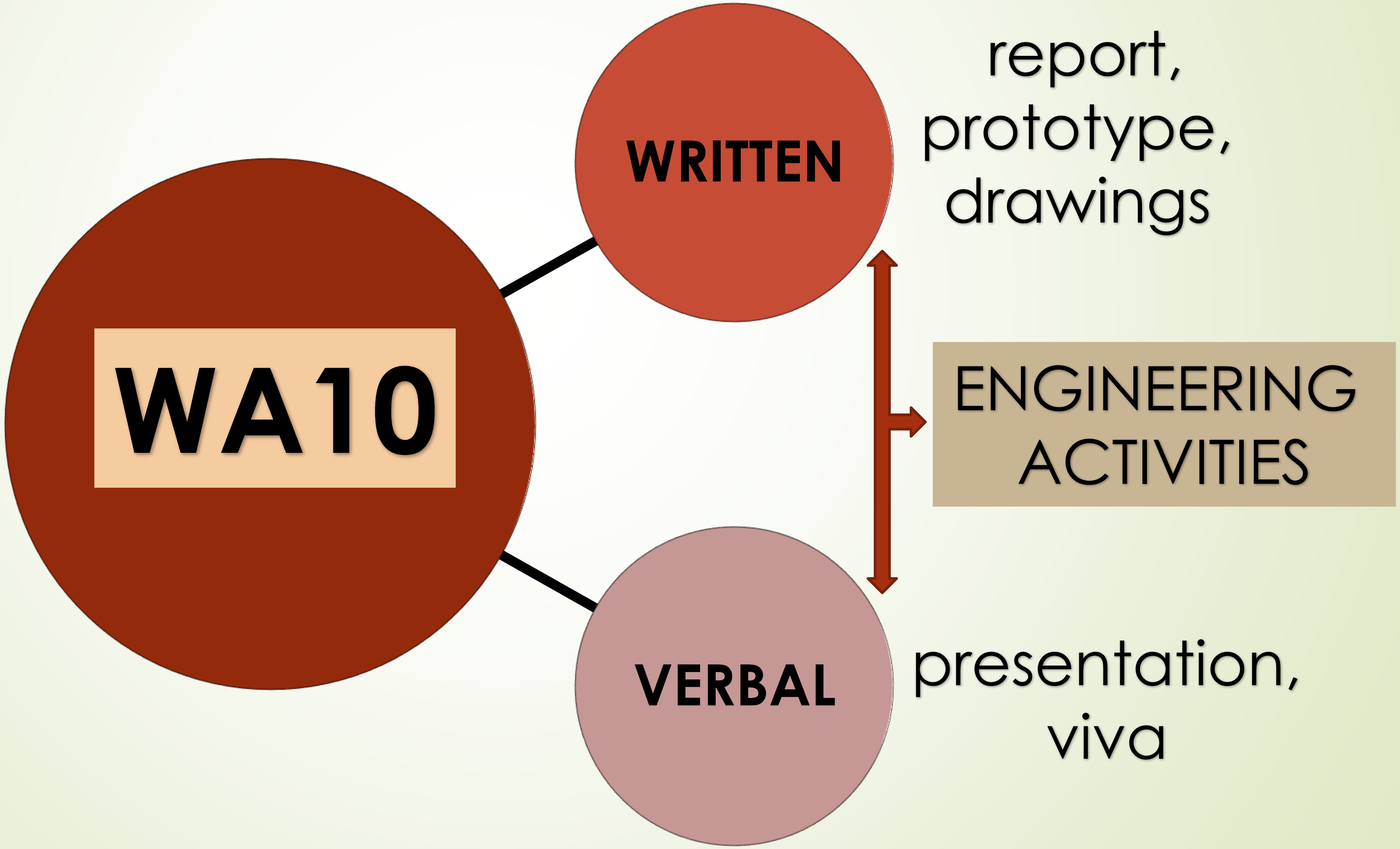
How does the illustrated example fulfill the following characteristics?

WP1	**Depth of knowledge required**	
WP2	**Range of conflicting requirements**	
WP3	**Depth of analysis required**	
WP4	**Familiarity of issues**	
WP5	**Extent of applicable codes**	
WP6	**Extent of stakeholder involvement and level of conflicting requirements**	
WP7	**Interdependence**	

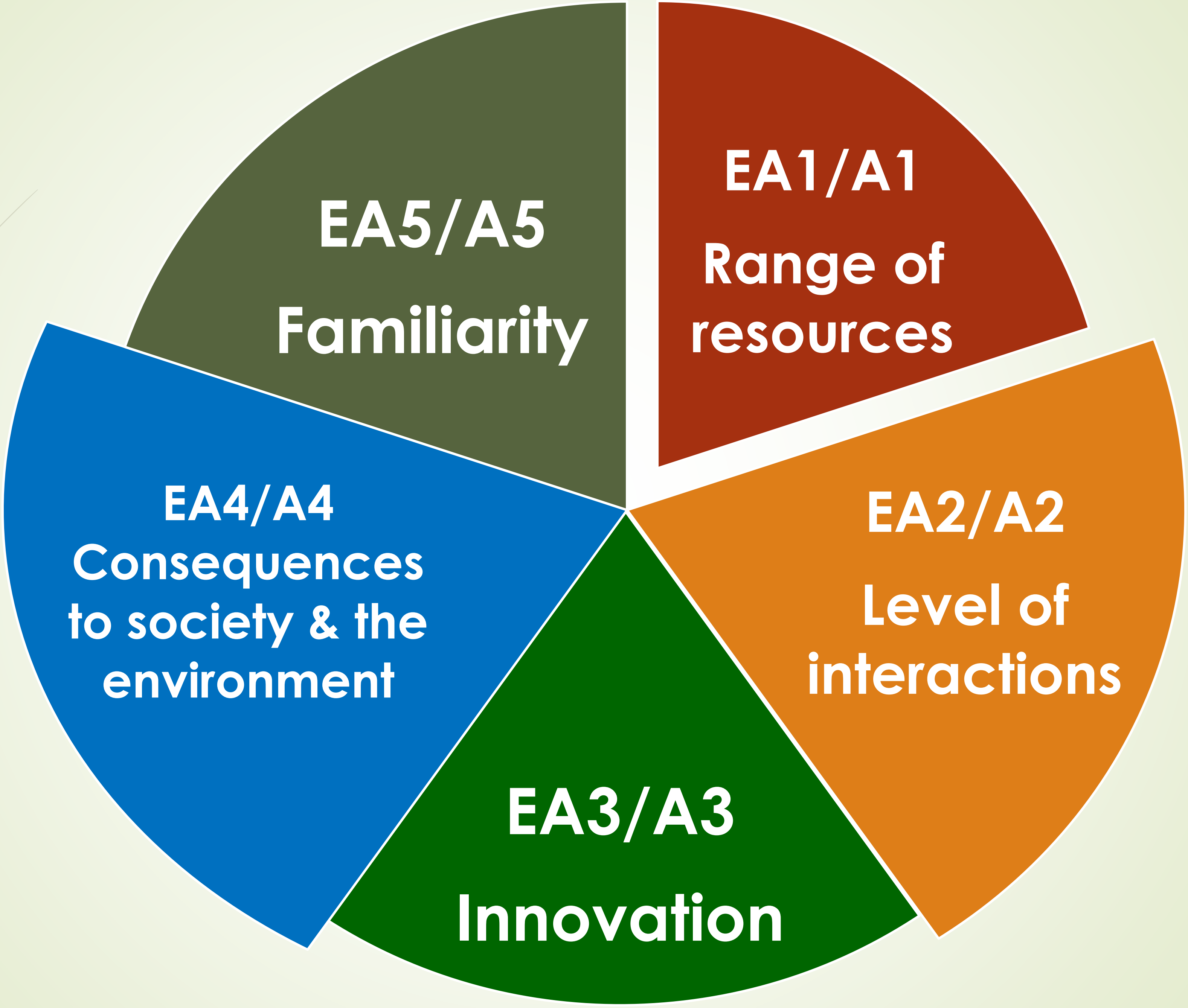
BREAK TIME

WA10: **COMMUNICATION** ~ COMPLEX ENGINEERING ACTIVITIES

COMMUNICATE effectively on **complex engineering activities** with the engineering community and with society, able to comprehend, write, present, give and receive instructions



COMPLEX ENGINEERING ACTIVITIES – (some OR ALL of EA1/A1-EA5/A5)



CAN BE REASONABLY ENCOUNTERED DURING IDP & INDUSTRIAL TRAINING

KEYWORD	BAETE MANUAL 2019, 2nd ed. (TABLE 4.3) – COMPLEX ENGINEERING ACTIVITIES (A1-A5) CHARACTERISTICS
Range of resources	**A1** involve the use of **diverse resources** (and for this purpose resources includes people, money, equipment, materials, information and technologies)
Level of interactions	**A2** require resolution of **significant problems** arising from **interactions between wide-ranging or conflicting technical, engineering or other issues**
Innovation	**A3** involve **creative use** of engineering principles and research-based knowledge in novel ways
Consequences to society and the environment	**A4** have **significant consequences** in a range of contexts, characterized by difficulty of prediction and mitigation
Familiarity of issues	**A5** can extend **beyond** previous experiences by applying principles-based approaches

EA1	Range of resources	Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies).

What resources were available to help you carry out this engineering activity?

Negotiate adequate resources eg personnel, funding, equipment, authorisations to undertake work materials

Develop plans (including budgets) to schedule availability of resources for allocation when required to meet project timelines and financial commitments.

Report work progress against schedule – work-flow plans, budgets, overall project performance objectives and provide projections on work completion to target times and budget

EA2	Level of interactions	Require resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues.

What are the engineering issues or other issues that could impact on engineering matters related to the project - the expected outset of the project ?

What unforeseen engineering issues arose during the execution of the project ?

Prior to commencing the work to 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 respective proposed solution.

EA3	**Innovation**	**Involve creative use of engineering principles and research-based knowledge in novel ways**

What new techniques, materials or processes can be utilised in the project, feasibility study (technical & economy), literature review ?

How do the proposed approach improve the efficiency, effectiveness or quality of work? Such as *ROI, quality, economy and sustainability*.

What are the creative solutions and out of the box thought processes undertaken/happened to promote innovation ?

EA4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.

What are the impacts of the engineering solution on the society and environment?

Who is affected and how?

EA5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.

To what extent is the previous experiences routinely encountered and resolved using well-understood practices?

The experience is a:

a. New experience which is not previously or only rarely encountered.
b. Familiar experience with either:
   - Clearly defined approaches and/or practices used to resolve.
   - Some (or many) unique issues that made communication difficulty level increases.

INTERNAL AUDIT AND MODERATION

CHECKLIST

- *PROGRAMME OUTCOME MEASURED IS WA10*
- *CHECK FOR EA1-EA5*
- *CHECK THE WRITTEN EVIDENCES AGAINST THE RUBRICS*
- *CHECK THE RUBRICS AGAINST THE EXPECTED ORAL PRESENTATIONS*
- *IDENTIFY THE COMPLEX ENGINEERING ACTIVITIES CHARACTERISTICS*
- *REPORT YOUR FINDING*

PO		X
WA10	COMM	

A		X
EA1	Range of resources	
EA2	Level of interactions	
EA3	Innovation	
EA4	Consequences to society and the environment	
EA5	Familiarity	

RUBRIC DESIGN

3 – For Discussion

STEP 1 - DEFINE THE PROBLEM

WP?

Problem Statement

- It was observed that a number of unauthorised vehicles enter the campus without valid car stickers. The security guards check for the unauthorised vehicles for valid stickers at the entrance throughout the day which is a potential health and safety hazard at workplace. At times, the entrance to the campus experiences high volume of traffic. Design an access system to address the above issues with minimum cost implication to the university.

Performance Criteria

1. The design must be low cost, utilising existing infrastructures whenever possible
2. The design must be able to reduce the risk of health and safety hazard to the security guards
3. The design must not build up the traffic at the entrance of the campus

STEP 2 – GATHER INFORMATION

(Search for Information & Record the Results)

WP?
EA?

- The team of students gathered information on the existing solutions to the problem which include touch card and wide range RFID access system, number plate recognition system, and others. They interviewed the security guards, the Security Department which issues the car stickers and few of the manufacturers of various access systems.
- From the interview with the Security Department, the team asked the permission to access the existing CCTV system if needed.
- The information gathered at this stage also allowed the team to chart the project plan (Gantt Chart), identify risks and resources needed for the project, and so on.

STEP 3 - GENERATE MULTIPLE SOLUTIONS

WP?
EA?

- The team discussed the various types of access systems, the technical and non-technical requirements.
- The touch card access system was found to be taking more time per car entry while the wide range RFID access system required lesser time. The team also considered the use of Number Plate Recognition system which requires the same amount time or less as per the wide range RFID access system. This consideration is an important performance criterion (no. 3).
- The team also worked out the pricing of the abovementioned systems as part of the requirement of performance criterion (no. 2). The number plate recognition system was found to be cheapest among the various solutions as it could utilise the existing CCTV system though required more extensive programming.

STEP 4 – ANALYSE AND SELECT A SOLUTION

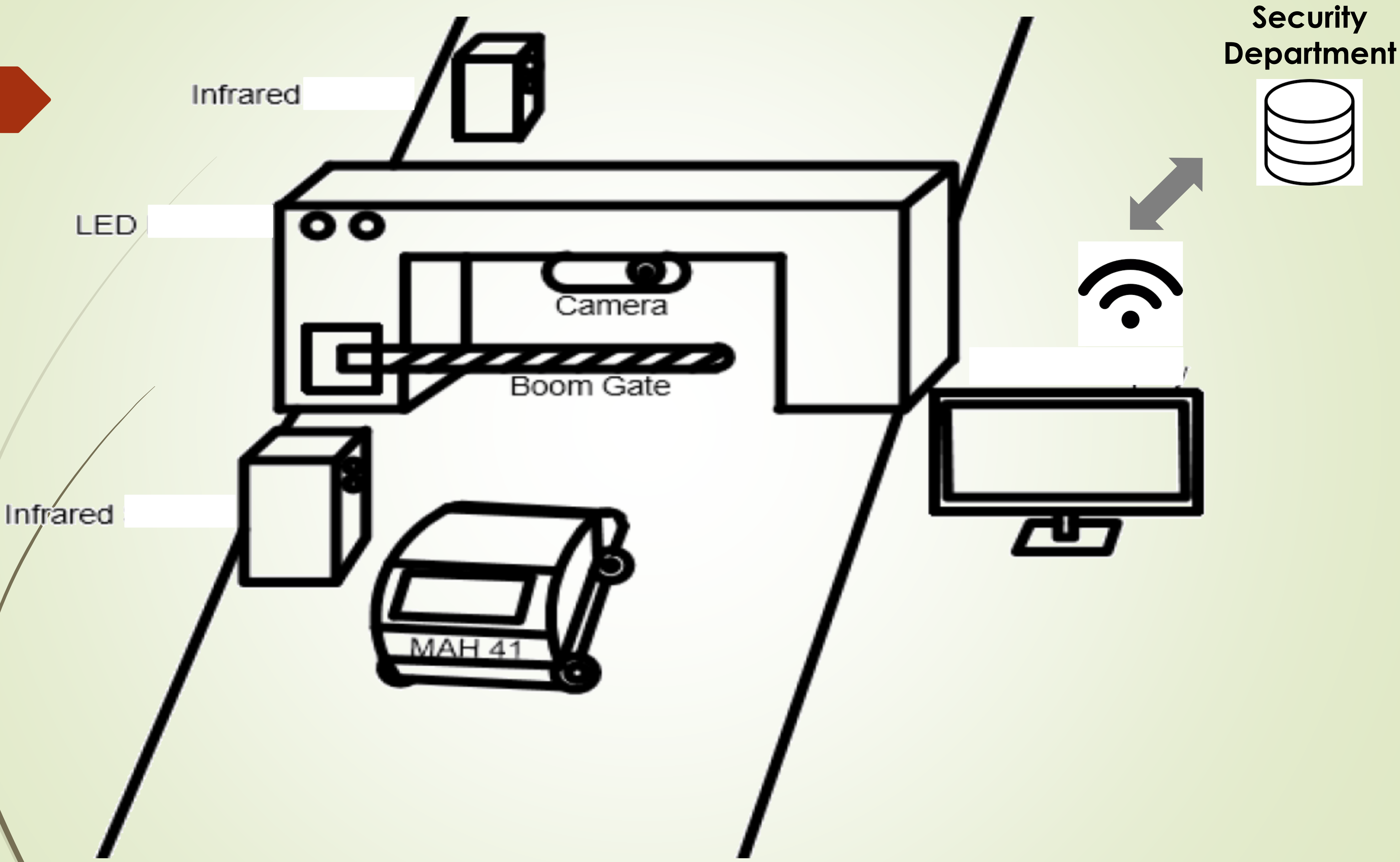
WP?

- The team selects the most suitable solution based on the following analyses:
  1. **Functionality analysis**
     Both wide range RFID access system and number plate recognition system need the least time per car entry thus would minimise the traffic at the entry to the campus.
  2. **Economic analysis**
     Touch card and wide range RFID would require a car reader to be installed and issuance of access cards while number plate recognition system could utilise the existing CCTV system.
  3. **Health and safety**
     All mentioned solutions would improve the health and safety hazard of the workplace.
- Based on the above analyses, the team decided on number plate recognition system which requires the application of engineering knowledge of digital signal/image processing, programming, embedded system, instrumentation, storage and matching of information in the database, among others.

STEP 5 - TEST AND IMPLEMENT SOLUTION

- This step includes prototyping and documenting the solution such as engineering drawing, written communication, scheduling and planning, etc. and **presentation to the faculty members or public.**

WA10 on Communication – Complex Engineering Activities


Security
Department
Infrared
LED
Camera
Boom Gate
Infrared
MAH 41

How does the illustrated example fulfill 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.	

Kul Sharif Mosque (White Mosque)
Kazan Kremlin, Russia, 16th century
(rebuilt 1996-2005)

Group Discussion

1. Can we address all WP1-WP7 in 1 course?
2. Provide an example on how to assess each of the WP1-WP7 and EA1-EA5?

COURSES FOR IMPLEMENTING COMPLEX ENGINEERING PROBLEMS

- **Industry-based Integrated Design Project**
  - Employed Problem-Based Learning teaching method
  - Provides students opportunity to apply their skills and knowledge toward developing a robust understanding of what it means to be an engineer
  - Supports students to make transition from classroom-based activities to professional communities of practices
  - Working with a supervisor from the industry in a type of collaboration, students are challenged with a real-world problem.
- **Final Year Project**
  - Commonly known as research project
  - Best means of introducing an investigative research-oriented approach to engineering studies and sourcing of knowledge externally from the real-world
  - Involves review of open research literature which challenges students to interpret new information, perform critical analysis, form personal opinions and judgements, and learn independently
  - Open research literature is one of the assessments that employs constructivist technique.

COURSES FOR IMPLEMENTING COMPLEX ENGINEERING PROBLEMS

- **Industry Training or Work-based Learning**
  - Provides opportunities for students to engage in experiential education, integrating theory with work experience
  - Provides students with knowledge base and skills to help them translate isolated and abstract concepts into practical applications of that knowledge.
- **Laboratory experiences**
  - Important elements in engineering education, bridging the gaps between engineering theories and real practices through cultivation of hands-on skills
  - Open-ended approach - the problem may have multiple solutions and there is no obvious solution. Being a subset of problem-based learning, open-ended laboratory focuses on student's ability to design experiments, identify the variables or results or information to be collected and identify the appropriate instruments for the assigned problem. This approach suits the need to produce engineering graduates that are self-directed, reflective, demonstrate ability to integrate knowledge, think critically, practice life-long learning and work collaborative with others.

USE OF FINAL EXAMINATION FOR COMPLEX PROBLEM SOLVING

- **Many believe that examination is not suitable to assess complex engineering problem solving skills and it must involve activities, especially integrated activities and discussions, such as case study (Phang *et al*., 2018).**

- **Example of final examination question (Phang *et al*., 2018):**

Sungai Melana is a small river flowing through several residential areas in Skudai, Johor Bahru. You are a consultant appointed to propose a river restoration action plan for a part of Sungai Melana, beginning from the upstream at Taman Teratai until the midstream at Taman Universiti.

Your proposal should include action plans to accomplish the following objectives:

1. Improving the water quality of Sungai Melan to Class II and III
2. Prevention of direct solid waste discharge into the river system
3. Creating suitable habitats for the propagation aquatic life
4. Adding property and aesthetic value to residents living along the river

Your answers should be written to address each of these items separately.

Sharing Further Info

RUBRICS DESIGN – DESCRIPTORS FOR WP/EA CHARACTERISTICS

- The existing rubrics practiced by the institutions of higher learning in assessing programme outcomes can be enhanced by the following **suggested descriptors to highlight the significance of complex engineering problems or complex engineering activities**.
- Depending on the nature of the problems or activities, some of these descriptors could be used.

WP	CHAR	Rubrics Design KNOWLEDGE		1	2	3	4	5
WP1	Depth of Knowledge WK3 - EF WK4 - SK WK5 - ED WK6 - EP WK8 – RL	Analyse the problem using specified knowledge profile Evaluate the problem under such circumstance towards providing an effective solution	Weightage	Use 2 WKs but do not elaborate Evaluate 1 circumstance only	Use 2 WKs with acceptable elaboration Evaluate 2 circumstances with acceptable justification	3	4	>4
WP2	Conflicting require-ments	Compare the conflicting technical, engineering and other issues arising to solve the problem Assess the conflicting requirements and provide a satisfactory proposal towards solving the problem.		Only 1 issue Assess but no proposal	Compare 2 issues with acceptable discussion Assess with 1 proposal	Compare 2 issues with acceptable discussion Assess with 2 proposal	3	>3
WP3	Depth of analysis	Develop the formulae/procedures to solve the problem using suitable models. Justify creativity towards the achievement of the formulae/procedures		Conceptualise 1 formula used Justify the 1 creative development	Conceptualise 1 formula used but do not elaborate the model Justify the 1 creative development used but do not elaborate the model	Develop 1 formula used and elaborate the model Justify the 1 creative development used and elaborate the model	2	3

WP	CHAR	Rubrics Design KNOWLEDGE		1	2	3	4	5
WP4	Familiarity of issues	Differentiate the infrequently encountered issues in problem solving Select formulae/procedures to resolve the infrequently encountered issues	Weightage	Compare the basis. Select an approach to resolve.	Compare and differentiate 2 issues Select 2 approaches to resolve	Differentiate 2 issues and propose Select 2 approaches to resolve and justify	3	>3
WP5	Extent of applicable codes	Develop solution using standards and codes of practice for professional engineering Justify professional engineering experiences to resolve the problem solving		Use at least 1 Justify using at least 1 experience	Use at least 2 Justify using at least 2 experiences	Use at least 2 and include practising guide Justify using 2 experiences and select at least 1	3	>3
WP6	Extent of stake-holder	Differentiate the diverse groups of stakeholders with widely varying needs. Select stakeholder interests and requirements that give impact on the problem		Compare the basis. Select a stakeholder and discuss impact.	Compare and differentiate 2 groups Select 2 stakeholders and compare impacts.	Differentiate 2 groups and propose 1 solution Select 2 stakeholders and justify impacts.	3	>3
WP7	Interde-pendence	Analyse high level problems including many component parts or sub-problems. Propose problem broken down into smaller components or sub-problems.		Use 2 sub problems but do not elaborate Propose 1 component only	Use 2 sub problems with acceptable elaboration Propose 2 components	Use 2 sub problems and differentiate Propose 2 components with acceptable justification	3	>3

EA	CHAR	Rubrics Design		1	2	3	4	5
EA1	Range of resources	Elaborate functions and association with different resources such as people, money, equipment, materials, information and technologies Justify the involvement of these resources in fulfilling the requirements of a successful design project.	Weightage	Associate with 1 resource but do not elaborate Justify on 1 resource only	Associate with 1 resource with acceptable elaboration Justify on 1 resource with acceptable justification	2	3	>3
EA2	Level of interac-tions	Adapt significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues Justify the solutions achieved arising from the level of interactions involving wide-ranging or conflicting technical, engineering or other issues.		Associate with 1 level of interaction Discuss on the 1 level of interaction	Adapt 1 level of interaction Justify the 1 level of interaction	2	3	>3
EA3	Innova-tion	Advocate creative use of engineering principles and research-based knowledge in novel ways Justify creativity towards the achievement of the novelty (eg. patent/copyright/etc)		Conceptualise 1 creative principle used Justify the 1 creative principle used	Conceptualise 1 creative principle used but do not elaborate the novelty Justify the 1 creative principle used but do not elaborate research based knowledge	Advocate 1 creative principle used and elaborate the novelty Justify the 1 creative principle used and elaborate research based knowledge	2	3

EA	Characteristics	Rubrics Design : WRITING		1	2	3	4	5
EA4	Consequences to society and the environment	Organise significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation Exemplify significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation	Weightage	Organise and characterise 1 context Justify the consequences	Organise and characterise 1 difficult context Justify the difficulty and consequences	2	3	>3
EA5	Familiarity of issues	Organise resolution beyond previous experiences routinely encountered. Exemplify experiences to resolve the engineering activities		Organise by applying 1 principles-based approach. Justify the approach during resolution	Organise by applying 1 principles-based approach beyond previous experience. Justify the approach during resolution beyond previous experience	2	3	>3

OBE CURRICULA

CONSTRUCTIVE ALIGNMENT

Have programme educational objectives, programme outcomes, course outcomes and performance indicators/ criteria or rubrics

PEO,PO, CO,LO

Stated objectives and outcomes can be assessed and evaluated

Centered around the needs of the students and the stakeholders

STUDENT CENTRED

C/P/A

Programme outcomes address Knowledge, Skill & Attitude (C,P,A) to be attained by students

OUTCOMES

Course outcomes must satisfy the stated programme outcomes. There is no need for ANY (individual) course to address all programme outcomes.

Teaching/ Learning method may have to be integrated to include different delivery methods to complement the traditional LECTURING method.

ACTIVE LEARNING

CQI

Learning outcomes are intentional and assessed using suitable performance indicators

ELEMENTS OF COURSE DESIGN

WHAT Bloom's Taxonomy

Standard/EAC 2017

Course specific goals & objectives

learning outcomes

CLOSE LOOP

STUDENT

HOW TO KNOW

Formative, Summative, Course, Programme, Tools, Direct and Indirect

Classroom assessment techniques

Instructional Technology

Lectures

Labs

HOW TO HELP

instruction

assessment

Tests | Surveys | Others

Active & cooperative learning

Problem based learning

Other learning techniques

CDIO

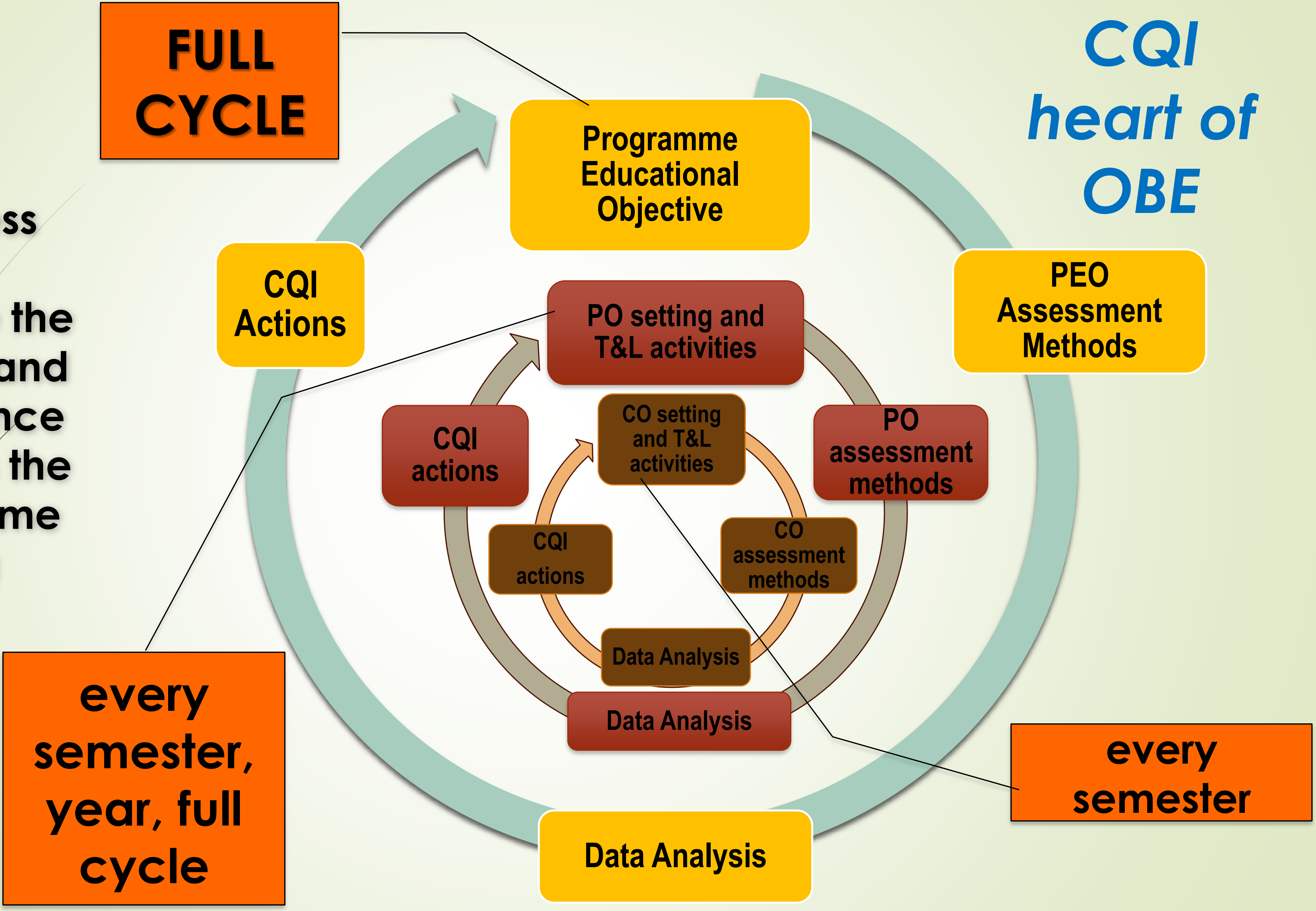
OBE requires T&L activities to be CONSTRUCTIVELY ALIGNED to intended learning outcomes

FELDER & BRENT, JEE, JAN., 2003

CQI process instituted

- Describe the process and significance of CQI in the programme planning

CQI heart of OBE



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POINTS FOR CLARIFICATIONS

- sitihawabthamzah@gmail.com
- liewcp@tarc.edu.my


Thank You