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International Experience on Graduate Attributes and Professional Competences (GAPC) and Accreditation

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INTERNATIONAL ENGINEERING ALLIANCE

International Standards/Benchmarks for Engineering Education & Professional Practice

INTERNATIONAL ENGINEERING ALLIANCE

The International Engineering Alliance (IEA)

- IEA is a global not-for-profit organisation, which comprises members from 41 jurisdictions within 29 countries, across seven international agreements.
- These international agreements govern the recognition of engineering educational qualifications and professional competence.
- Through the Educational Accords and Competence Agreements members of the International Engineering Alliance establish and enforce internationally bench-marked standards for engineering education and expected competence for engineering practice.

INTERNATIONAL ENGINEERING ALLIANCE

Role of the International Engineering Alliance

- The International Engineering Alliance (IEA) is an umbrella organisation for seven multi-lateral agreements which establish and enforce amongst their members inter-nationally-benchmarked standards for engineering education and what is termed “entry level” competence to practise engineering.
- The IEA’s core activities:
  - Consistent improvement of standards and mobility
  - Defining standards of education and professional competence
  - Assessment of education accreditation and evaluation of competence
  - Participation in activities that are driven from the engineering profession.

IEA

Accords

- 3 Accords
  - Washington Accord – tertiary level engineering education
  - Sydney Accord – engineering technology education
  - Dublin Accord – engineering technician education

Agreements

- 4 Agreements
  - IPEA – Professional engineers
  - APEC – Professional engineers
  - IETA – Engineering technologists
  - AIET – Engineering technicians

The Washington Accord

- Originally 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.
- As with the other accords the signatories are committed to development and recognition of good practice in engineering education.
- The activities of the Accord signatories (for example in developing exemplars of the graduates' profiles from certain types of qualification) are intended to assist growing globalization of mutual recognition of engineering qualifications.
- The Washington Accord is specifically focused on academic programmes which deal with the practice of engineering at the professional level.

The Washington Accord

- The Accord acknowledges that accreditation of engineering academic programmes is a key foundation for the practice of engineering at the professional level in each of the countries or territories covered by the Accord.
- The Accord outlines the mutual recognition, between the participating bodies, of accredited engineering degree programmes. It also establishes and benchmarks the standard for professional engineering education across those bodies.

Washington Accord Signatories

- **Korea** - Represented by Accreditation Board for Engineering Education of Korea (ABEEK) (2007)
- **Russia** - Represented by Association for Engineering Education of Russia (AEER) (2012)
- **Malaysia** - Represented by Board of Engineers Malaysia (BEM) (2009)
- **China** - Represented by China Association for Science and Technology (CAST) (2016)
- **South Africa** - Represented by Engineering Council South Africa (ECSA) (1999)
- **New Zealand** - Represented by Engineering New Zealand (EngNZ) (1989)
- **Australia** - Represented by Engineers Australia (EA) (1989)
- **Canada** - Represented by Engineers Canada (EC) (1989)
- **Ireland** - Represented by Engineers Ireland (EI) (1989)
- **Hong Kong China** - Represented by The Hong Kong Institution of Engineers (HKIE) (1995)
- **Chinese Taipei** - Represented by Institute of Engineering Education Taiwan (IEET) (2007)
- **Singapore** - Represented by Institution of Engineers Singapore (IES) (2006)
- **Sri Lanka** - Represented by Institution of Engineers Sri Lanka (IESL) (2014)
- **Japan** - Represented by JABEE (2005)
- **India** - Represented by National Board of Accreditation (NBA) (2014)
- **United States** - Represented by Accreditation Board for Engineering and Technology (ABET) (1989)
- **Turkey** - Represented by Association for Evaluation and Accreditation of Engineering Programs (MÜDEK) (2011)
- **United Kingdom** - Represented by Engineering Council United Kingdom (ECUK) (1989)

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Washington Accord Signatories

→ **Bangladesh** - Represented by The Institution of Engineers Bangladesh (IEB) (2023)

Provisional Status Approved in 2016. Full Signatory Status recognition from 2023

→ **Costa Rica** - Represented by Colegio Federado de Ingenieros y de Arquitectos de Costa Rica (CFIA) (2020)

→ **Mexico** - Represented by Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI) (2022)

→ **Pakistan** - Represented by Pakistan Engineering Council (PEC) (2017)

→ **Peru** - Represented by Instituto de Calidad y Acreditacion de Programas de Computacion, Ingenieria y Tecnologia (ICACIT) (2018)

→ **Philippines** - Represented by Philippine Technological Council (PTC) (2023)

Recognition date as full signatory status applies from 2023 to Tier 1 programmes as defined by the tier classification system used in the Philippines.

→ **Indonesia** - Represented by Indonesian Accreditation Board for Engineering Education (IABEE) (2022)

PROVISIONAL SIGNATORIES ARE RECOGNISED AS HAVING APPROPRIATE SYSTEMS AND PROCESSES IN PLACE TO DEVELOP TOWARDS BECOMING A FULL SIGNATORY

→ **Chile** - Represented by Agencia Acreditadora Colegio De Ingenieros De Chile S A (ACREDITA CI)

Provisional Status Approved in 2018.

→ **Thailand** - Represented by Council of Engineers Thailand (COET)

Provisional Status Approved in 2019.

→ **Myanmar** - Represented by Myanmar Engineering Council (MEngC)

Provisional Status Approved in 2019.

→ **Saudi Arabia** - Represented by Education and Training Evaluation Commission (ETEC)

Provisional Status Approved in 2022

→ **Nigeria** - Represented by Council for the Regulation of Engineering in Nigeria (COREN)

Provisional Status Approved in 2023

→ **Mauritius** - Represented by Institution of Engineers Mauritius (IEM)

Washington Accord

- The signatory for each jurisdiction is the recognised organisation for accreditation of professional engineering qualifications.
- Signatories agree to grant (or recommend to the relevant national registration body, if different) graduates of each other's accredited programmes the same recognition, rights and privileges as they grant to graduates of their own accredited programmes.
- By these provisions, the Accord facilitates mobility of graduates between signatory jurisdictions and deeper understanding and recognition of their engineering education and accreditation systems.
- Amongst the signatories' educational providers, adherence to local accreditation requirements that are consistent with the professional engineer graduate attribute exemplar contributes to international benchmarking of programme outcomes.

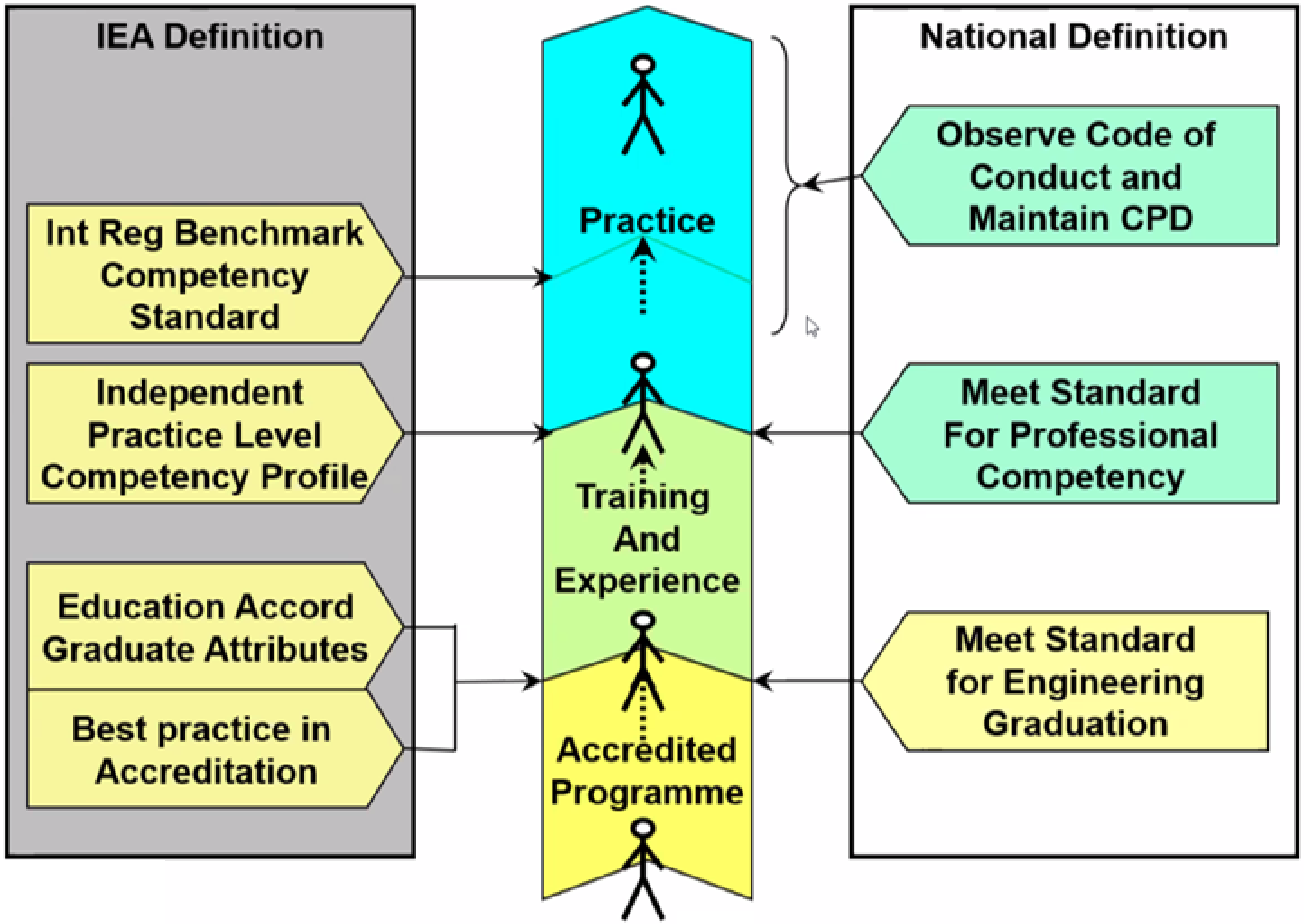
Multilateral Agreement Among WA Signatories

- The signatories of the Washington Accord mutually recognize programs accredited by other signatories in satisfying the academic requirements for the practice of engineering at the professional level.
- The recognition is based on substantial equivalence of education programs:
  - The accredited programs attain the same **standards**;
  - Accreditation evaluation is performance under substantially equivalent **governance framework and procedure**

Substantial Equivalence

- The objective of using substantial equivalence is to avoid prescriptive standards requiring detailed compliance.
- Substantial equivalence of engineering degree programs accredited by WA Signatories: while different programs might take a different approach in engineering education, the same overall educational outcomes are achieved.
- Substantial equivalence of accreditation decision is realized when accreditation decision made corresponds to the accreditation decision of a program from the Accord reviewer's signatory with substantially equivalent outcomes.

Comparing National Systems using IEA norms



OVERVIEW -
Development of GAPC

Background

- IEA published the guiding document *Graduate Attributes and Professional Competencies* (GAPCs) to provide differentiable benchmarks for outcomes-based engineering education and professional competency profiles.
- The Accords Signatories evaluate the substantial equivalence of programmes accredited by signatories based on both the Graduate Attributes and the best practice indicators for evaluating programme quality listed in the Accords' Rules and Procedures.
- Similarly, the Agreements Members establish substantial equivalence using the stipulated set of professional competency profile.
- The 2013 version of GAPCs was widely adopted by IEA Signatories and Members in setting their respective outcome-based or competency-based assessment standards.
- The adoption varied from full-set adoption to a form of substantial equivalence.

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Graduate Attributes

- The graduate attributes adopted by the Washington Accord signatories are generic to the education of professional engineers in all engineering disciplines.
- They categorise what graduates should know, the skills they should demonstrate and the attitudes they should possess.
- The graduate attributes have been refined over more than a decade and in 2013 were adopted by the signatories as the exemplar (or reference point) against which substantial equivalence of their own accreditation requirements are to be assessed.
- In addition, the graduate attributes are intended to assist signatories and provisional members to develop outcomes-based accreditation criteria for use by their respective jurisdictions.

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Purpose of Graduate Attributes

- *Graduate attributes* form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practise at the appropriate level. The graduate attributes are exemplars of the attributes expected of graduate from an accredited program. Graduate attributes are clear, succinct statements of the expected capability, qualified if necessary, by a range indication appropriate to the type of program.
- The graduate attributes are intended to assist Signatories and Provisional Members to develop or review their outcomes-based accreditation criteria for use by their respective jurisdictions. Graduate attributes also guide bodies in developing or revising their accreditation systems with a view to seeking signatory status.
- Graduate attributes are defined for educational qualifications in the engineer, engineering technologist and engineering technician tracks. The graduate attributes serve to identify the distinctive characteristics as well as areas of commonality between the expected outcomes of different types of programs.

Quality of Programs

Graduate Attributes and the Quality of Programs

The Washington, Sydney and Dublin Accords "recognize the substantial equivalence of … programs satisfying the academic requirements for practice …" for engineers, engineering technologists and engineering technicians respectively. The Graduate Attributes are assessable outcomes, supported by level statements, developed by the signatories that give confidence that the educational objectives of programs are being achieved. The quality of a program depends not only on the stated objectives and attributes to be assessed but also on the program design, resources committed to the program, the teaching and learning process and assessment of students, including confirmation that the graduate attributes are satisfied. The Accords therefore base the judgement of the substantial equivalence of programs accredited by signatories on both the Graduate Attributes and the best practice indicators for evaluating program quality listed in the Accords' Rules and Procedures[2].

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Application of Graduate Attributes

Best Practice in Application of Graduate Attributes

The attributes of Accord programs are defined as a *knowledge profile*, which is an indicated volume of learning and the attributes against which graduates must be able to perform. The requirements are stated without reference to the design of programs that would achieve the requirements. Providers therefore are free to design programs with different detailed structures, learning pathways and modes of delivery. Evaluation of individual programs is the concern of national accreditation systems.

Limitation of Graduate Attributes

Limitation of Graduate Attributes

Each signatory defines the standards for the relevant track (engineer, engineering technologist or engineering technician) against which engineering educational programs are accredited. Each educational level accord is based on the principle of *substantial equivalence*; that is, programs are not expected to have identical outcomes and content but rather produce graduates who could enter employment and be fit to undertake a program of training and experiential learning leading to professional competence and registration. The Graduate Attributes provide a point of reference for bodies to describe the outcomes of substantially equivalent qualification. The Graduate Attributes do not, in themselves, constitute an “international standard” for accredited qualifications but provide a widely accepted common reference or benchmark for bodies to describe the outcomes of substantially equivalent qualifications.

Graduate Attributes may be accepted for use within a jurisdiction or adapted to accommodate the context and any specific requirements of the jurisdiction. Where a signatory has adapted or developed their own graduate attributes, it is expected that there is alignment to these Graduate Attributes.

The term graduate does not imply a particular type of qualification but rather the exit level of the qualification, be it a degree or diploma.

Contextual Interpretation

- The graduate attributes are stated generically and are applicable to all engineering disciplines.
- In interpreting the statements within may be amplified and given particular emphasis but they must not be altered in substance or individual elements ignored. a disciplinary context, individual statements

Version 1

- A single process was therefore agreed to develop the three sets of graduate attributes and three professional competence profiles.
- An International Engineering Workshop (IEWS) was held by the three educational accord and the two mobility fora in London in June 2004 to develop statements of Graduate Attributes and International Register Professional Competence Profiles for the Engineer, Engineering Technologist and Engineering Technician categories.
- The resulting statements were then opened for comment by the signatories. The comments received called for minor changes only.
- The Graduate Attributes and Professional Competences were adopted by the signatories of the five agreements in June 2005 at Hong Kong as version 1.1.

Version 2

- A number of areas of improvement in the Graduate Attributes and Professional Competences themselves and their potential application were put to the meetings of signatories in Washington DC in June 2007.
- A working group was set up to address the issues.
- The IEA workshop held in June 2008 in Singapore considered the proposals of the working group and commissioned the Working Group to make necessary changes with a view to presenting Version 2 of the document for approval by the signatories at their next general meetings.
- Version 2 was approved at the Kyoto IEA meetings, 15-19 June 2009.

Version 3

- 2012 signatories performed an analysis of gaps between their respective standards and the Graduate Attribute exemplars and by June 2013 most signatories reported substantial equivalence of their standards to the Graduate Attributes.
- This will be further examined in periodic monitoring reviews in 2014 to 2019.
- In this process a number of improvements to the wording of the Graduate Attributes and supporting definitions were identified.
- The signatories to the Washington, Sydney and Dublin Accords approved the changes resulting in this Version 3 at their meetings in Seoul 17-21 June 2013.
- Signatories stated that the objectives of the changes were to clarify aspects of the Graduate Attribute exemplar. There was no intent to raise the standard. The main changes were as follows:
  - New Section 2.3 inserted;
  - Range of problem solving in section 4.1 linked to the Knowledge Profiles in section 5.1 and duplication removed;
  - Graduate Attributes in section 5.2: cross-references to Knowledge Profile elements inserted; improved wording in attributes 6, 7 and 11;
  - Appendix A: definitions of *engineering management* and *forefront of discipline* added.

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Version 4

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GRADUATE ATTRIBUTES & PROFESSIONAL COMPETENCIES

PROUDLY SUPPORTED BY:

World Federation of Engineering Organizations
Fédération Mondiale des Organisations d'Ingénieurs

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Background

- IEA published the guiding document *Graduate Attributes and Professional Competencies* (GAPCs) to provide differentiable benchmarks for outcomes-based engineering education and professional competency profiles.
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GAPC 2021

- A UNESCO-WFEO-IEA Working Group was established in November 2019 following the renewal of the WFEO-IEA MoU and the Declaration on Engineering Education that was made in Melbourne at WEC2019.
- The Working Group has reviewed the Graduate Attributes and Professional Competencies in order to ensure that they reflect contemporary values and employer needs, cover diversity and inclusion and ethics to reflect current and emerging thinking, address the intellectual agility, creativity and innovation required of engineering decision making as well as equipment engineering professionals of the future to incorporate the practices that advance the United Nations Sustainability Development Goals.
- The proposed revisions were introduced and discussed by member organizations through a series of extensive consultations, also through webinars organized by WFEO, in IEAM 2020 by IEA members, and via consultation web pages.

Major changes

1. There were changes in all tables on Range of Problem Solving, Range of Engineering Activities, Knowledge and Attitude Profile, Graduate Attributes, and Professional Competence Profiles. These consisted of additions of new attributes as well as enhancements of the already existing ones. Some improvements in the wording and in clarity has also been a concern.
2. Knowledge and Attitude Profile, Graduate Attributes, and Professional Competence Profiles Tables now refer to UN SDG. These references are intended to provide context for curriculum designers and for professional engineers seeking registration. They represent an internationally accepted example of how sustainability issues can be concisely understood and presented.
3. Two rows on “Consequences, Judgement” at the end of Table 4.1 Range of Problem Solving that refer to Professional Competences are deleted as no differentiation was deemed necessary among the three categories.
4. A new row of “Ethics, inclusive behavior and conduct” is introduced in the Knowledge Profile table, the name of which has been changed to the Knowledge and Attitude Profile.

Major changes

5. The breadth required of engineering education has been widened to emphasize digital literacy, data analysis, UN SDG, knowledge of relevant social sciences.
6. Two rows of Graduate Attributes on “The Engineer and Society” and “Environment and Sustainability,” which have been based on the same knowledge profile have been combined under the heading “The Engineer and the World,” also supplementing the required knowledge profile.
7. Knowledge and awareness of ethics, diversity, and inclusion have been emphasized.
8. Critical thinking, innovation, emerging technologies, and lifelong learning requirements have been highlighted.
9. The necessitated similar changes to Professional Competences have also been made.

A CLASSIFICATION BASED ON KEY-WORDS OF CHANGE (contributed by Prof Arif Bulent Ozguler – Deputy Chair, WA)

DIGITIZATION/ AUTOMATION	WA1: Apply knowledge of ... computing and engineering fundamentals	WA8: Function effectively ... in ... remote and distributed settings	WA11: ... adaptability to new and emerging technologies	WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science	
DIVERSITY/ INCLUSION	WA7: ... commit to professional ethics and norms ... Demonstrate an understanding of the need for diversity and inclusion	WA9: Communicate effectively and inclusively	WA8: Function effectively ... as a member or leader in diverse and inclusive teams	WK9: Ethical attitude, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes	
CREATIVITY	WA2: Identify, formulate, research literature	WA4: Investigate ... problems using research methods including research-based knowledge	WA3: Design creative solutions	WA5: Create ... techniques, resources, ... and IT tools	WA11: ... ability for ... critical thinking
BROADER VIEW	WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences	WK8: ... awareness of the power of critical thinking, creative approaches to evaluate emerging issues.			
CONTINUOUS DEVELOPMENT	WA11: Recognize the need for, and have the preparation and ability-for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change	EC11: Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work			
SUSTAINABILITY	WA3: Design ... solutions ... with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations	WA4: Investigate ... with holistic considerations for sustainable development	WA6: ...evaluate sustainable development impacts ...	WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area	WK7: Knowledge of the role of engineering in society and identified issues in engineering practice ... such as the professional responsibility of an engineer to public safety and sustainable development*

Knowledge and Attitude Profile

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice are as in the engineering discipline; much is at the forefront of the discipline.
WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area
WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development*
WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes

*Represented by the 17 UN Sustainable Development Goals (UN-SDG)

Old Version 3 - Washington Accord Knowledge Profile	
WK1	A systematic, theory-based understanding of the **natural sciences** applicable to the discipline
WK2	Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline
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
WK7	**Comprehension of** the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability
WK8	Engagement with selected knowledge in the **research literature** of the discipline
A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 4 to 5 years of study, depending on the level of students at entry.	

Range of Problem Identification and Solving

Complex Engineering Problems

Attribute	Complex Engineering Problems have characteristic WP1 and some or all of WP2 to WP7
Depth of Knowledge Required	WP1: 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
Range of conflicting requirements	WP2: Involve wide-ranging and/or conflicting technical, non-technical issues (such as ethical, sustainability, legal, political, economic, societal) and consideration of future requirements
Depth of analysis required	WP3: Have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate suitable models
Familiarity of issues	WP4: Involve infrequently encountered issues or novel problems
Extent of applicable codes	WP5: Address problems not encompassed by standards and codes of practice for professional engineering
Extent of stakeholder involvement and conflicting requirements	WP6: Involve collaboration across engineering disciplines, other fields, and/or diverse groups of stakeholders with widely varying needs
Interdependence	WP 7: Address high level problems with many components or sub-problems that may require a systems approach

Old Version 3 - Washington Accord Complex Engineering 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 fundamentals-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 conflicting requirements	Involved diverse groups of stakeholders with widely varying needs
WP7 Interdependence	Are high level problems including many components parts or sub-problems

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Range of Engineering Activities

Attribute	Complex Activities
Preamble	Complex activities means (engineering) activities or projects that have some or all of the following characteristics:
Range of resources	EA1: Involve the use of diverse resources including people, data and information, natural, financial and physical resources and appropriate technologies including analytical and/or design software
Level of interactions	EA2: Require optimal resolution of interactions between wide-ranging and/or conflicting technical, non-technical, and engineering issues
Innovation	EA3: Involve creative use of engineering principles, innovative solutions for a conscious purpose, and research-based knowledge
Consequences to society and the environment	EA4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
Familiarity	EA5: Can extend beyond previous experiences by applying principles-based approaches

Old Version 3 - Washington Accord Range of Engineering Activities		
Item	Attributes	Complex Activities means (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 ways
EA4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
EA5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches

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Engineering Knowledge: Breadth, depth and type of knowledge, both theoretical and practical	**WA1:** Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialization as specified in WK1 to WK4 respectively to develop solutions to complex engineering problems	WK1 – natural science & social science WK2 – mathematics, computer & information science WK3 – engineering fundamentals WK4 – Engineering specialist knowledge
Problem Analysis: Complexity of analysis	**WA2**: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences ~~with holistic considerations for sustainable development*~~ (WK1 to WK4)	WK1 – natural science & social science WK2 – mathematics, computer & information science WK3 – engineering fundamentals WK4 – Engineering specialist knowledge
Design/development of solution: Breadth and uniqueness of engineering problems i.e., the extent to which problems are original and to which solutions have not previously been identified or codified.	**WA3:** Design creative solutions for complex engineering problems and design systems, components or processes to meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required (WK5)	WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area

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Investigation: Breadth and depth of investigation and experimentation	**WA4:** Conduct investigations of complex engineering problems using research methods including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions (WK8)	WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
Tool Usage: Level of understanding of the appropriateness of technologies and tools	**WA5**: Create, select and apply, and recognize limitations of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems (WK2 and WK6)	WK2 – mathematics, computer & information science WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
The Engineer and the World: Level of knowledge and responsibility for sustainability development	**WA6**: When solving complex engineering problems, analyze and evaluate sustainable development impacts* to: society, the economy, sustainability, health and safety, legal frameworks, and the environment (WK1, WK5, and WK7) * *Represented by the 17 UN Sustainable Development Goals (UN-SDG)*	WK1 – natural science & social science WK5: Knowledge that supports engineering design and operations in a practice area WK7: Knowledge of the role of engineering in society

Ethics: Understanding and level of practice	**WA7**: Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9)	WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes
Individual and Collaborative Team Work: Role in and diversity of team	**WA8**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multi-disciplinary, face-to-face, remote and distributed settings (WK9)	
Communication: Level of communication according to type of activities performed	**WA9:** Communicate effectively and inclusively *on complex engineering activities* with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences.	

Project Management and Finance: Level of management required for differing types of activities	**WA10**: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multi-disciplinary environments.	
Lifelong Learning: Duration and manner	**WA11**: Recognize the need for, and have the preparation and ability for i) independent and life-long learning, ii) adaptability to new and emerging technologies, and iii) critical thinking in the broadest context of technological change (WK8)	WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues

Expectation 1 –
Timeline for Implementation of GAPC Version 4

Adoption of GAPC – Accords' Perspectives

1. Options for adoption of GAPC 2021
2. Adoption in totality
3. Adoption as reference benchmark in SE gap analysis
4. Expectations for signatories & provisional signatures
5. Sharing of challenges and best practices in adoption
6. Timelines for implementation

Adoption of GAPC – Accords' Perspectives

1. Options for adoption of GAPC 2021
   - Adoption in totality
   - Adoption as reference benchmark in SE gap analysis

Adoption of GAPC – Accords' Perspectives

4. Expectations for signatories & provisional signatories
    - Same for both signatories & provisional signatories (at transition to full signatories
    - Higher expectation for full signatories
    - Others

Accords	Proposed action
July 2024	Signatory: i) Attach a detailed road-map for adaptation and implementation in your Annual Report. ii) Complete the adaptation of the new version of the “local evaluation outcome criteria” to GA Version 4. iii) Indicate clearly which stage of the road map your organization is at.
	Provisional Signatory: i) Complete the adaptation of the new version of the “local evaluation outcome criteria” to GA Version. ii) Indicate clearly at which stage of the road map your organization is.

Accords	**Proposed action**
July 2025	IEA: i) Ask each signatory and provisional signatory to submit a “GAP analysis” by July 2026. ii) Provide a template that is based on the 2013 template (that served to examine substantial equivalence) for GAP analysis. iii) Establish a WG for the evaluation of the submitted GAP analyses and for preparing a feedback template that is based on the 2013 version.

Accords	Proposed action
July 2026	Signatory: i) Include, in your Annual Report, evidence that your adapted “local evaluation outcome criteria” is an accreditation criterion and is already being used. ii) Indicate the number of programs evaluated with the adapted criteria. iii) Indicate the date of completion, if different from the targeted date in your submitted road map. iv) Submit your GAP analysis.
	Provisional Signatory: i) Supply evidence that your adapted “local evaluation outcome criteria” is an accreditation criteria and has already been used. ii) Indicate the number of programs evaluated with the adapted criteria. iii) Indicate the date of completion, if different from the targeted date in your submitted road map. iv) Submit your GAP analysis.

Accords	Proposed action
July 2027	IEA: i) Give feedback to each signatory and provisional signatory on their submitted “GAP analysis.” ii) Provide a timeline for each signatory and provisional signatory for disposing of the reported deficiencies.

Expectation 2 -
Quality Assurance of Engineering Programs

INTERNATIONAL ENGINEERING ALLIANCE

Outcome-based Education & Accreditation

- Outcomes-based accreditation framework has widely been adopted as the benchmark for accreditation globally.
- Setting the appropriate measurable outcomes for objective assessment is crucial for differentiating various levels of technical education and for improving and assuring the quality and relevance of engineering education.
- Benchmarking outcomes-based accreditation system through international accords, such as the Washington Accord, facilitates multi-lateral recognition of substantial equivalency of programmes accredited by participating accreditation bodies.

The keys to quality assurance in engineering education

- Setting standards through Accreditation and Quality Assurance
- Program educational objective
- Curriculum development: Outcome-based education
- Faculty Excellence
- Students
- Teaching-Learning process – the pedagogy
- Facilities and learning environment
- Quality assurance: Governance and continuous quality improvement
- Interaction between educational institution and industry
- Research & Innovation

INTERNATIONAL ENGINEERING ALLIANCE

Evidence-based demonstration of Learning Outcomes

- Learning Activities and Assessment at the Required Depth & Breadth

Going beyond mapping exercises

Mapping of SLOs and PEOs

Student Learning Outcomes	Programme Educational Objectives (PEOs)			
	PEO#1	PEO#2	PEO#3	PEO#4
SLO1	•			
SLO2	•			
SLO3	•			
SLO4	•	•		
SLO5		•		
SLO6		•	•	
SLO7		•	•	
SLO8				•
SL09				•
SLO10		•		
SLO11		•		

Mapping of Courses to SLOs

	SLO 1	SLO 2	SLO 3	SLO 4	SLO 5	SLO 6	SLO 7	SLO 8	SLO 9	SLO 10	SLO 11	SLO 12
C1	2	3	3				2					1
C2	3	2	1					2				
C3												
C3		3	3			2				3	1	
C5												
C6												
C7												
C8												
C9												
C10												
C11												
C12												
1 – moderately support; 2- strongly support; 3 – very strongly support												

Mapping of Courses to Performance Indicators of SLOs

	SLO1			SLO2			SLO3			SLO3		
	PI1-1	PI1-2	PI1-3	PI2-1	PI2-2	PI2-3	PI3-1	PI3-2	PI3-3	PI4-1	PI4-2	PI4-3
C1		2	3		1		2	3				
C2	3		1	2		2				3	3	1
C3												
C4												
C5												
C6												
C7												
C8												
C9												
C10												
C11												
1 – moderately support; 2- strongly support; 3 – very strongly support												

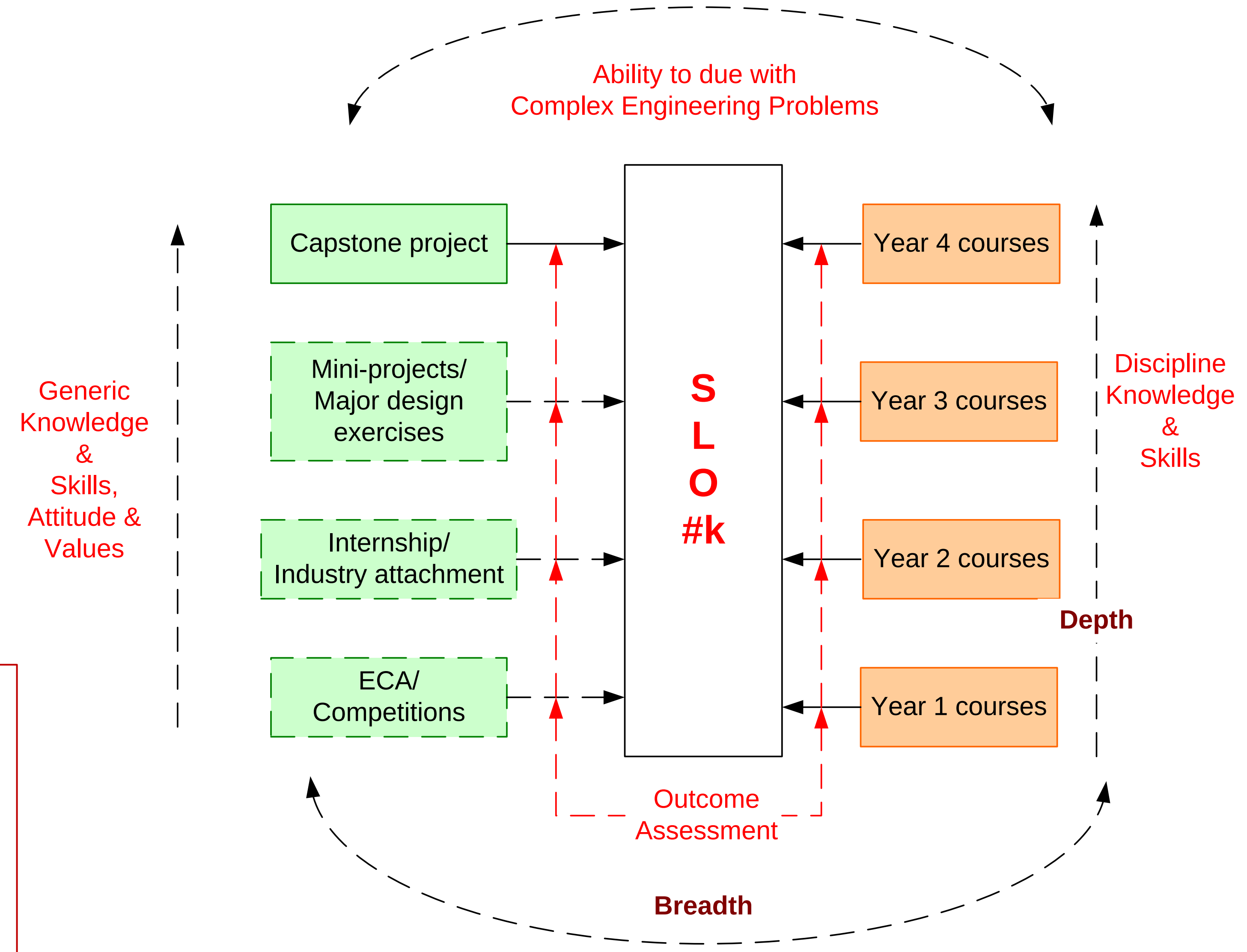
Evidences from various Teaching-Learning Activities

- Internship program
- Laboratory work
- Design projects
- Final year project
- Co-curricular activities to hone personal skills
- Assessment of learning outcomes
- Student feedback
- Others .....

SLO Folder

- For accreditation evaluation, good to prepare a folder for each outcomes
- Contains relevant subjects and assessment details which support achievement of the SLO
- Includes other student learning activities and assessment details
- Samples of student work

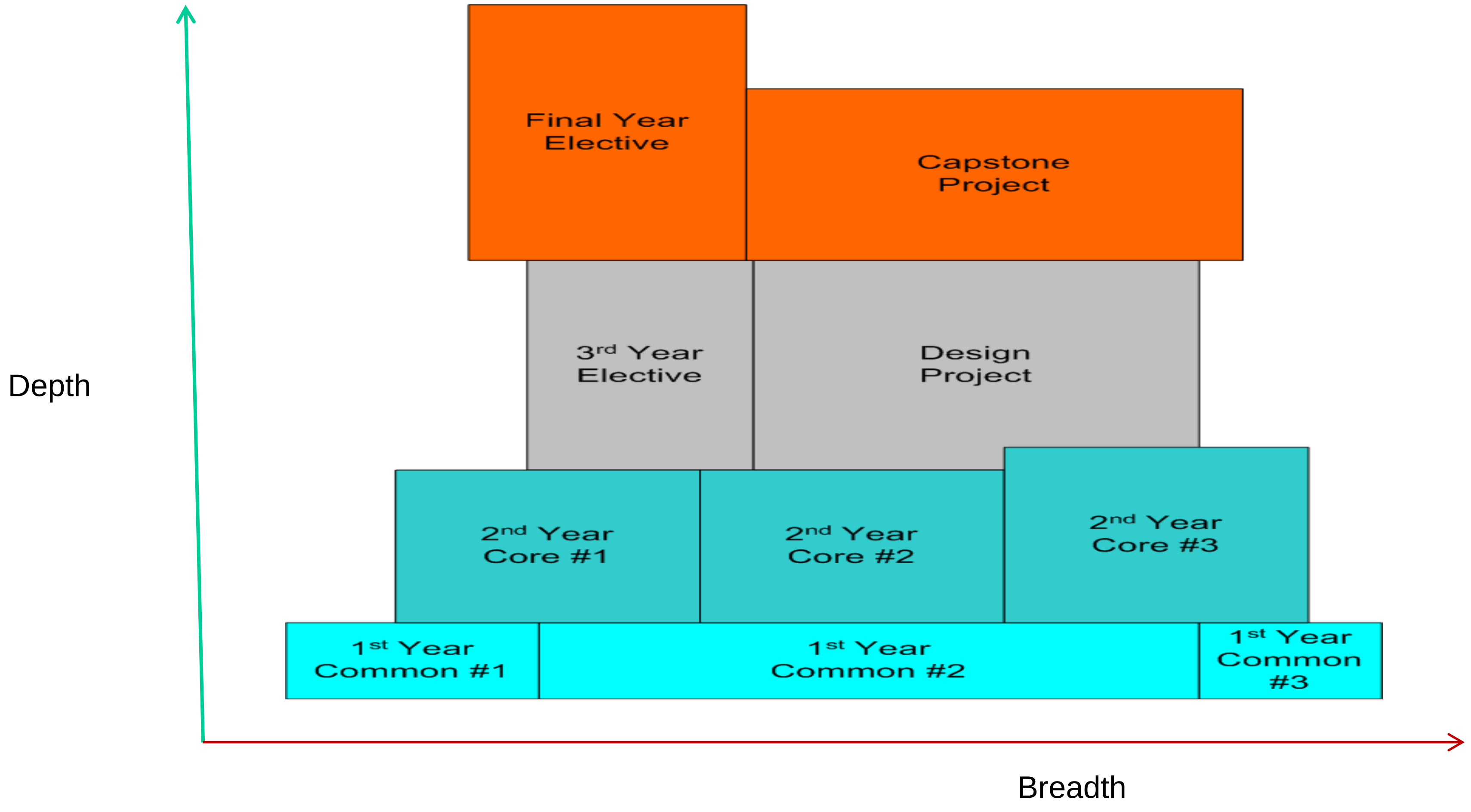
The achievement of each SLO, both breadth and depth, should be assessed and evaluated.

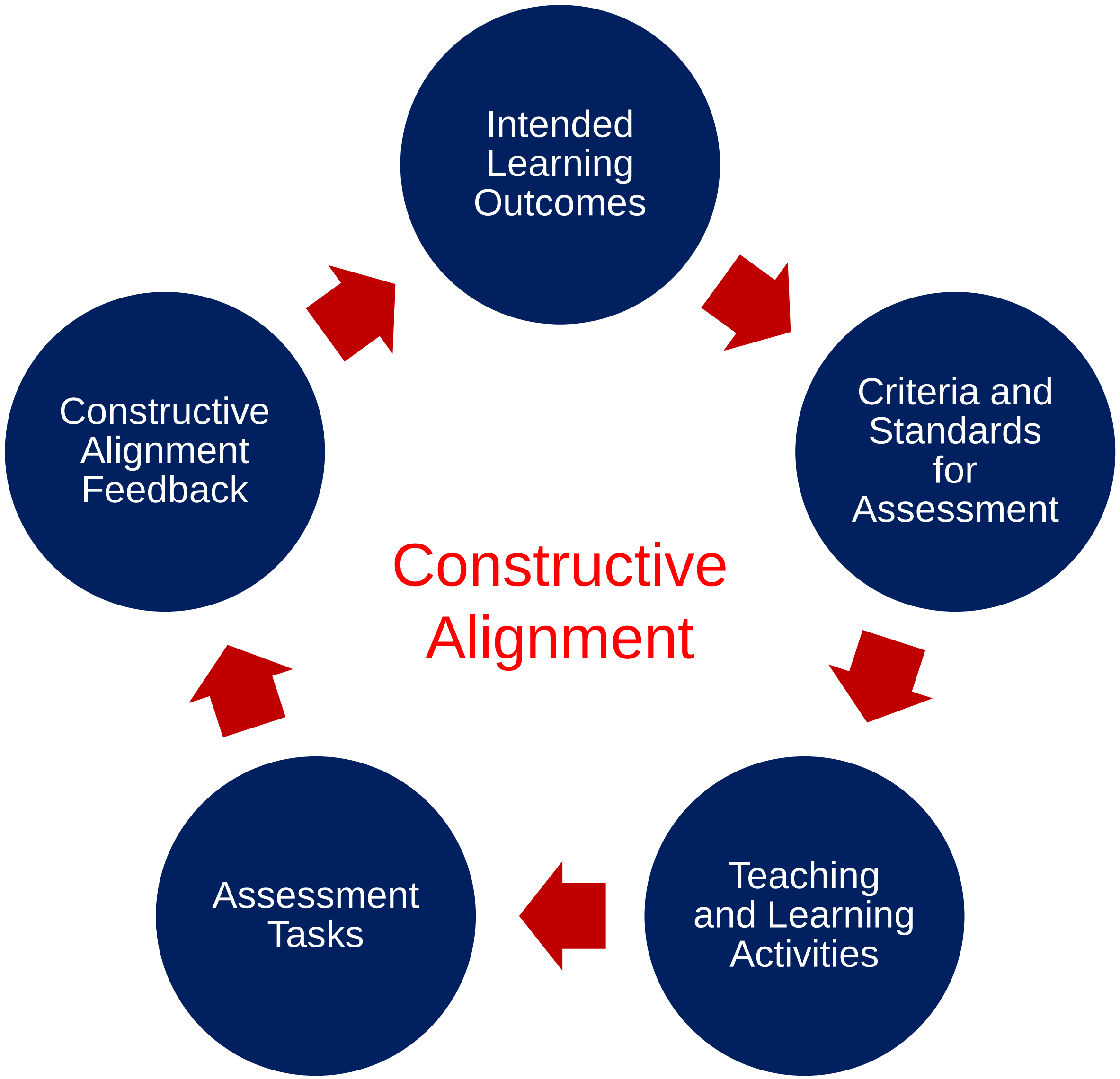


Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialization, as specified in WK1 to WK4 respectively, to the solution of complex engineering problems.

SLO xxxx

The achievement of each SLO, both breadth and depth, is dependent on learning activities over the years




Intended Learning Outcomes
Criteria and Standards for Assessment
Teaching and Learning Activities
Assessment Tasks
Constructive Alignment Feedback
Constructive Alignment

Expectation 3 –

Skill-oriented & Attitude-oriented Graduate Attributes

&

SDGs

SINGAPORE INSTITUTE OF TECHNOLOGY

Washington Accord

Graduate attributes

Knowledge-oriented

Apply engineering knowledge (WA1)

Problem-solving skill group

Problem analysis (WA2)

Design/Development of Solution (WA3)

Investigation (WA4)

Skill-oriented group

Tool Usage (WA5)

Individual and Collaborative Team-Work (WA8)

Communication (WA9)

Project Management and Finance (WA10)

Attitude-oriented group

The Engineer and the World (WA6)

Ethics (WA7)

Lifelong Learning (WA11)

Skill-oriented and Attitude-oriented Graduate Attributes

DIVERSITY/ INCLUSION	WA7: ... commit to professional ethics and norms ... Demonstrate an understanding of the need for diversity and inclusion	WA9: Communicate effectively and inclusively	WA8: Function effectively ... as a member or leader in diverse and inclusive teams	WK9: Ethical attitude, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes	
CREATIVITY	WA2: Identify, formulate, research literature	WA4: Investigate ... problems using research methods including research-based knowledge	WA3: Design creative solutions	WA5: Create ... techniques, resources, ... and IT tools	WA11: ... ability for ... critical thinking
BROADER VIEW	WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences	WK8: ... awareness of the power of critical thinking, creative approaches to evaluate emerging issues.			
CONTINUOUS DEVELOPMENT	WA11: Recognize the need for, and have the preparation and ability-for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change	EC11: Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work			
SUSTAINABILITY	WA3: Design ... solutions ... with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations	WA4: Investigate ... with holistic considerations for sustainable development	WA6: ...evaluate sustainable development impacts ...	WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area	WK7: Knowledge of the role of engineering in society and identified issues in engineering practice ... such as the professional responsibility of an engineer to public safety and sustainable development*

SUSTAINABLE DEVELOPMENT GOALS

Challenge statements can fall under one or more of the 17 UN SDGs

SINGAPORE INSTITUTE OF TECHNOLOGY

Competency-Based Education at SIT

Competency-Based Education (CBE) approach

- Key principle: Learning is best measured by learners demonstrating mastery of competencies.
- Superior approach to upskilling / reskilling, with high degree of personalised learning, and flexibility for the learner.

Area	Traditional	Competency-Based Education
Goal of Educational Encounter	Prioritizes the transmission of knowledge from teacher to learner.	Prioritises the demonstration by learner of industry-relevant competencies ('what one can do with what one knows').
Curriculum Design	Often starts with a set of topics considered important in the discipline.	Starts with the competencies required for job role(s) in the industry.
Instruction	Fixed curriculum for all learners, fixed timetable spanning one term, instructor-paced.	Accommodates learner needs, learner-paced, learning can take place at anytime, anyplace. Allows for Recognition of Prior Learning (RPL).
Assessment	Typically pen and paper, indirect, proxy assessments of knowledge.	Authentic, performance-based assessments that demonstrate mastery of specific competencies.

Competency-based Stackable Micro-credential (CSM)

- SIT launched the Competency-based Stackable Micro-credential (CSM) pathway with the first undergraduate degree programme in Applied Computing in 2023 as a pilot.

Two key aspects:

1) Competency-Based Education (CBE) approach
   - ➢ Focus on mastery of competencies (Knowledge, Skills & Abilities or KSAs) that are relevant to a job role.

2) Stackable Micro-Credentials
   - ➢ Programme design and delivery.

Micro-Credentials
- Sized & designed to provide a substantial body of competencies that are useful for the learner to apply in a job role in 3-6 months.

➕

Stackable
- towards a degree programme
  - ➢ fulfils aspirations of individuals
  - ➢ provides coherent body of competencies for a career in a disciplinary area or profession

We are piloting a new model of the future with the CSM pathway….

"Another significant effort by SIT and the industries today is the way in which they confer the micro-credentials. It is not just about getting a general degree, but **micro-credentials that are relevant and specific to the industry needs**. In this partnership, **SIT needs the inputs of our industries, especially the frontier industries**.

That is why the **designing of micro-credentials** by SIT together **with the rest of the industries** is so important, for us to **stay ahead of the game for both individuals and the industry**."

Speech from Mr. Chan Chun Sing, Minister for Education at SIT's MOU signing ceremony for the Competency-based Stackable Micro-credentials pathway in Nov 2022

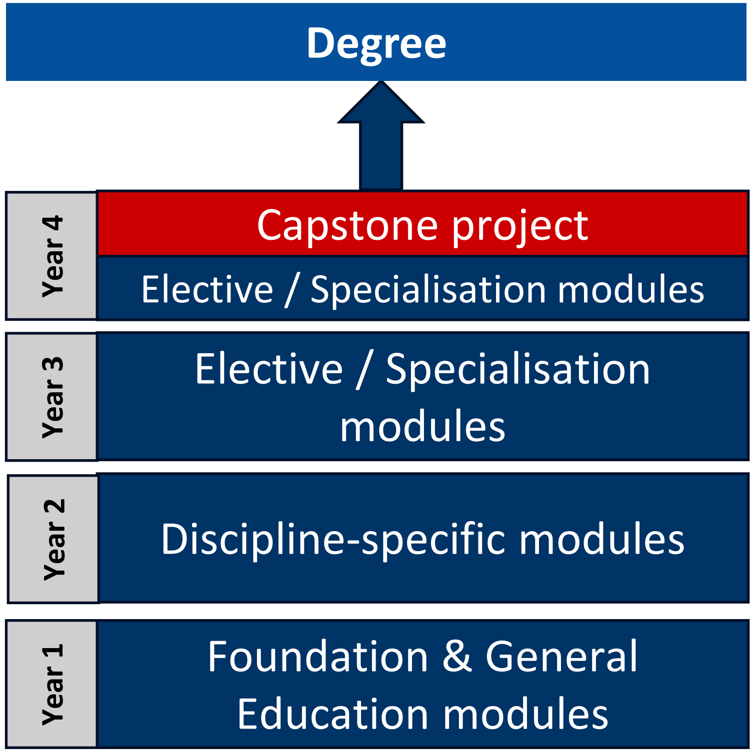
SIT SINGAPORE INSTITUTE OF TECHNOLOGY

SIT pilots pathway for working adults to upskill in ICT sector with stackable qualifications

Education Minister Chan Chun Sing (back row, third from left), was the guest of honour at the event where the Singapore Institute of Technology inked a memorandum of understanding with three industry partners and three polytechnics. ST PHOTO: LIM YAOHUI

Traditional degree programme

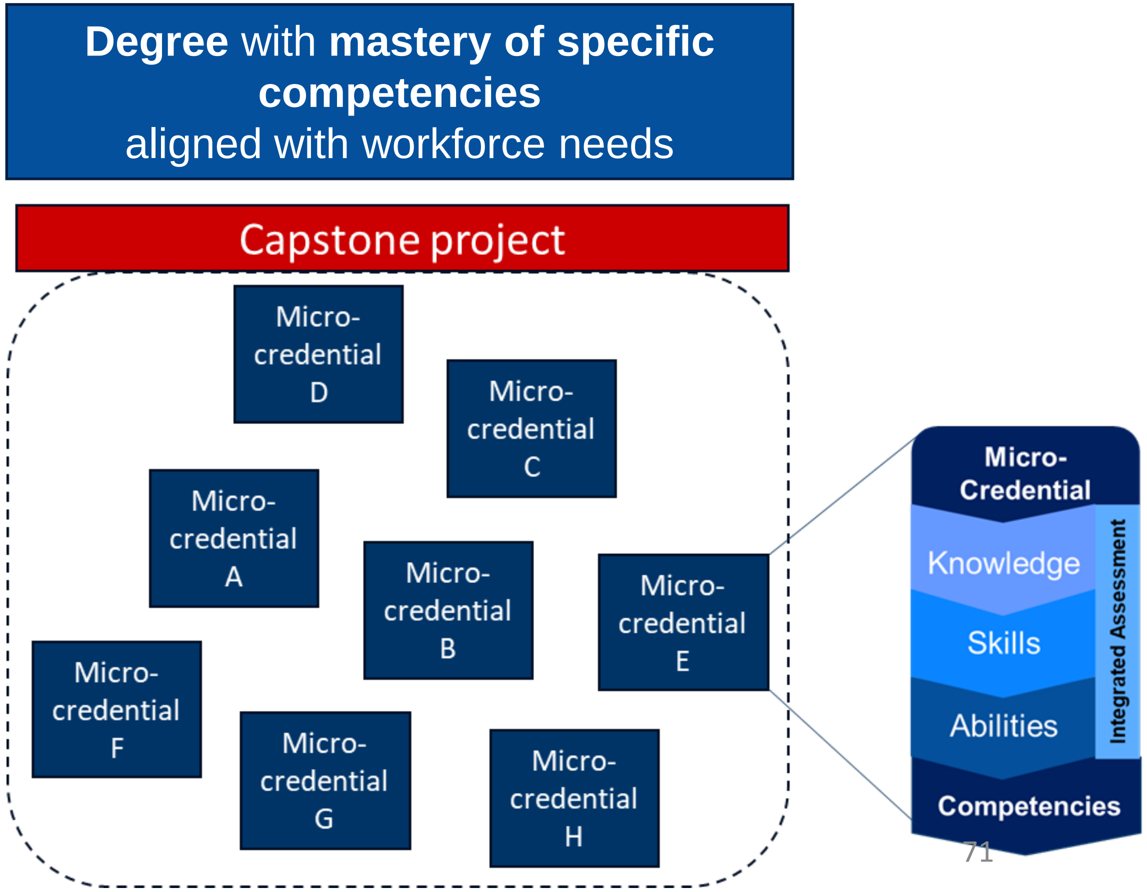
- Degree programmes are traditionally built on a collection of modules.
- Programme is designed on the principle of scaffolding of learning, i.e., more advanced modules built upon the foundation of knowledge acquired earlier in the programme.



- In practice, learners face major challenges:
  - Modules are developed and delivered in isolation from each other. "Pre-requisites" are used to weakly link the modules together.
  - Learners do not appreciate the context of where the knowledge (e.g. a topic in Maths) is applied.
  - The collection of siloed modules means that learners are left to connect the bodies of knowledge on their own. Some modules may be many months or years apart.
  - The capstone project is the major/sole integrative element but is left late towards the end of the programme.

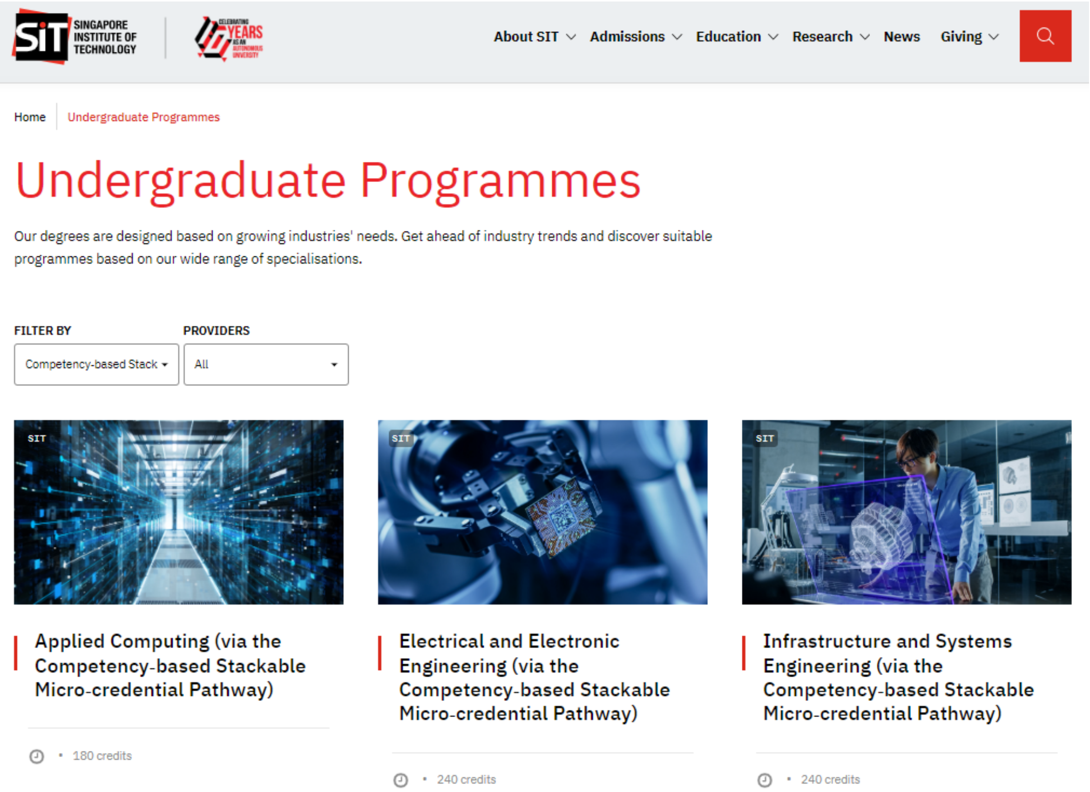
Micro-Credentials (MCs) as degree building blocks

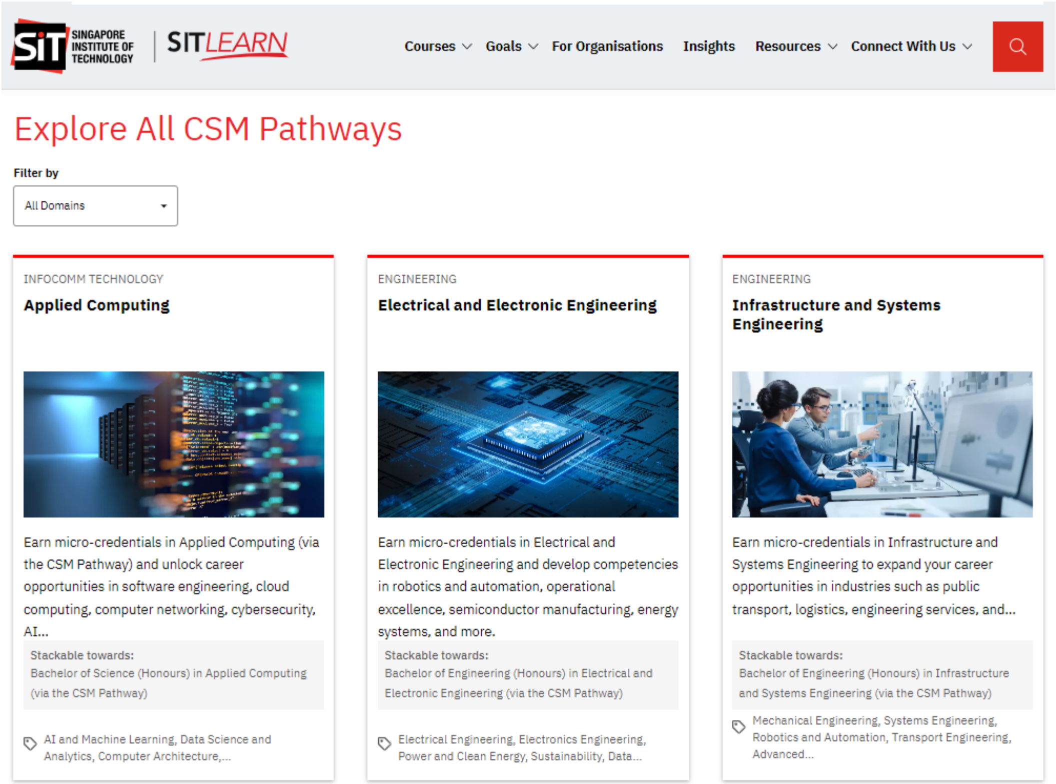
- We are pioneering a new degree construct where the degree is made up of a collection of Micro-Credentials (MCs).
- MCs need *not* be competency-based, but for our CSM-pathway programmes, we are adopting a competency-based approach as well.
- Each MC is self-contained. Key features:
  - ➢ Each MC is sized to be equivalent to 3 modules, sufficient to allow learners to gain a substantial set of competencies to fulfill a job role.
  - ➢ Topics are related and integrated to deliver the competencies and taught just-in-time. Includes an integrated assessment / project to tie the competencies together.
  - ➢ While the MC can be completed in 3-4 months, learners can pace their own learning
  - ➢ The MCs can be "stacked" towards a degree.



Engineering CSM

- In Sep 2024, SIT will be launching two new Engineering CSM programmes: 1) Electrical and Electronic Engineering (EEE) and 2) Infrastructure and Systems Engineering (ISE).

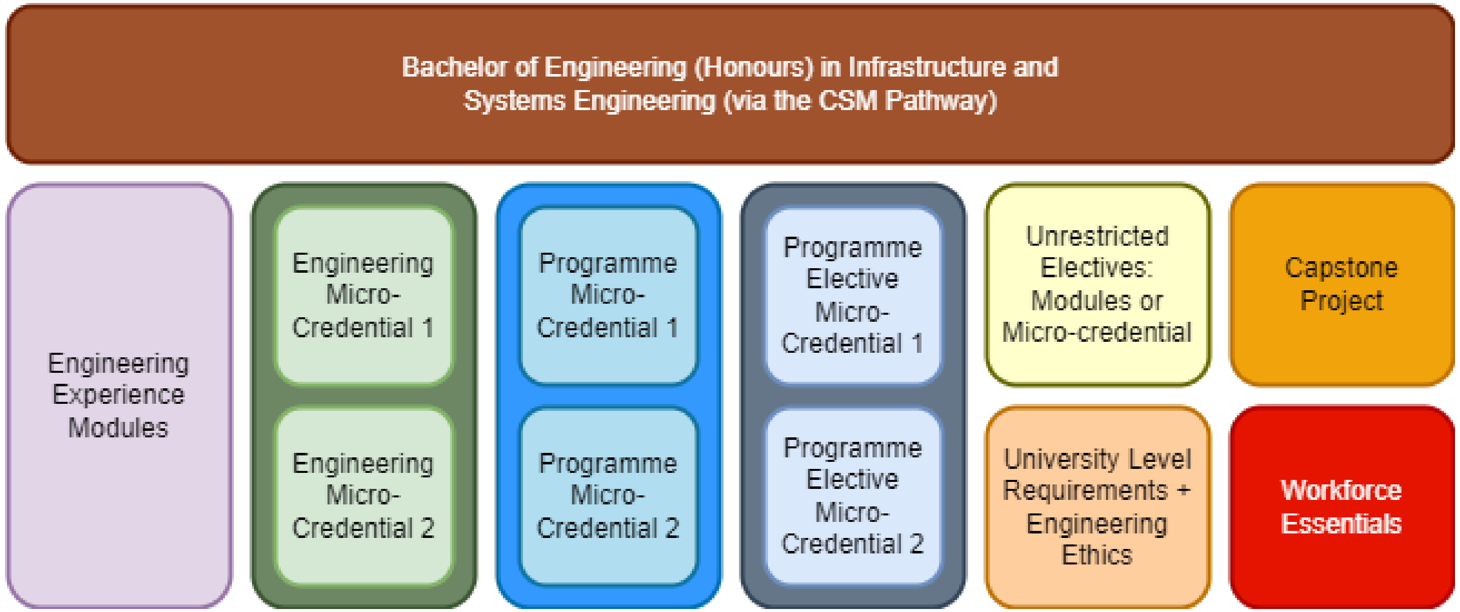




https://www.singaporetech.edu.sg/undergraduate-programmes/electrical-electronic-engineering-csm
https://www.singaporetech.edu.sg/undergraduate-programmes/infrastructure-systems-engineering-csm

Engineering CSM

- 4-year engineering programme (Learners with relevant engineering diplomas may be exempted from the Engineering Experience modules and proceed to take the micro-credentials)
- 6 Engineering MCs to provide the depth of knowledge and competencies required for an engineer



Engineering Micro-credentials

MC 1: Data Analytics for Engineers

- Python Programming and Data Engineering
- Data Analytics & Visualization
- Machine Learning in Engineering

MC 2: Operational Excellence in Engineering

- Process Management
- Total Quality Management
- Lean Six Sigma
- Supply and Inventory Management

- Two Engineering Micro-credentials are proposed in the area of data analytics and operational excellence which are common across different engineering disciplines.

Examples of Programme-related Micro-credentials

MC: Engineering Design and Solutioning

- 3D Modelling and Analysis
- Engineering Design Process
- Prototype Development

MC: Energy Systems Efficiency

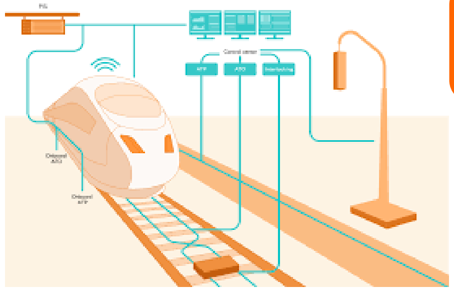
- Thermal Systems and Efficiency
- Modelling and Simulation
- Energy Analysis of Thermal Systems

MC: Smart Maintenance

- Condition-based Assets Monitoring
- Maintenance and Asset Management
- Industrial Internet-of-Things

MC: Robotics and Automation

- Robotics Manipulator
- Autonomous Robots
- Industrial Automation



MC: Railway Signalling and Communications

- Railway Signalling
- Railway Communications
- Safety in Railway Signalling and Communications

MC: Rolling Stock and Permanent Way

- Rolling Stock
- Permanent Way
- Safety in Rolling Stock and Permanent Way

Example of an Engineering MC:
“Engineering Design and Solutioning”

MC in Engineering Design & Solutioning

- This is an 18 credit MC, and one of the MCs that will be offered as a core component of the B.Eng degree in *Infrastructure and Systems Engineering*.

- MC prepares learners for roles in the precision engineering or engineering services sectors that involve working with engineering design and manufacturing, such as designer or engineer for engineering design.

- Learners should be able to design engineering systems and solutions by applying the engineering design process, while prioritizing human factors and considerations for manufacture. This includes the ability to:

  - Produce and interpret engineering drawings of complex engineering assemblies to predict and simulate their performance and behaviour;

  - Analyse and select appropriate machine elements and their materials for specific applications, and

  - Integrate them as working engineering systems by applying latest industry methods.

Traditional curriculum design

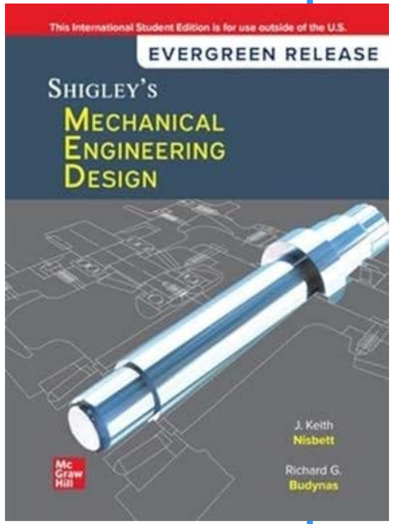


TABLE OF CONTENTS DESCRIPTION

Part 1 - Basics
1) Introduction to Mechanical Engineering Design
2) Materials
3) Load and Stress Analysis
4) Deflection and Stiffness
Part 2 - Failure Prevention
5) Failures Resulting from Static Loading
6) Fatigue Failure Resulting from Variable Loading
Part 3 - Design of Mechanical Elements
7) Shafts and Shaft Components
8) Screws, Fasteners, and the Design of Nonpermanent Joints
9) Welding, Bonding, and the Design of Permanent Joints
10) Mechanical Springs
11) Rolling-Contact Bearings
12) Lubrication and Journal Bearings
13) Gears - General

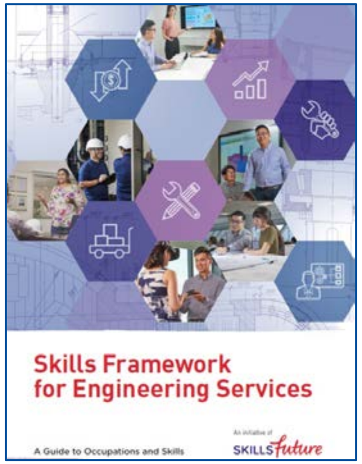
Traditional Approach

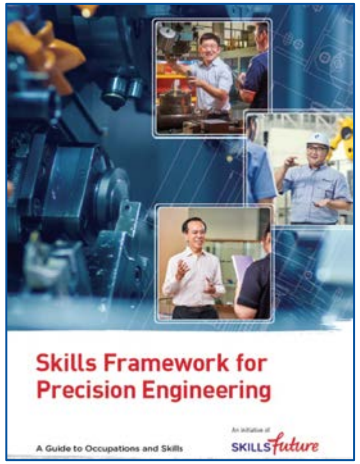
Typically starts with the adoption of a standard textbook and delivering selected topics from the textbook weekly.

Assessments are scheduled in the middle and end of the teaching term.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 8	Topic 10	Quiz	Topic 12	Topic 13	Topic 15	Topic 17	Topic 18	Exam

CBE curriculum design starts with the job roles & competencies





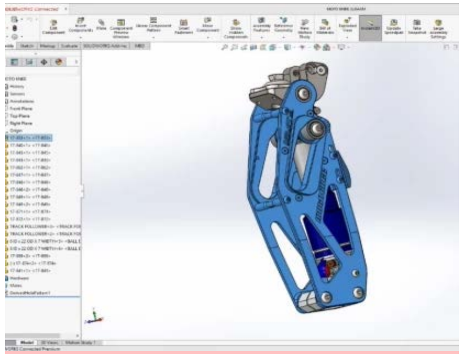
CBE Approach

Role	Related Technical Skills & Competencies
Product Engineer/ Product Designer	• 3D Modelling • Design for Safety • Engineering Drawing and Design Specification • Engineering Drawing Interpretation and Management
Engineer (Engineering Design)	• Additive Manufacturing • Computer-aided Design • Engineering Product Design • Manufacturing Technology

Inputs from industry

Assessments are then developed for learners to demonstrate mastery of competencies

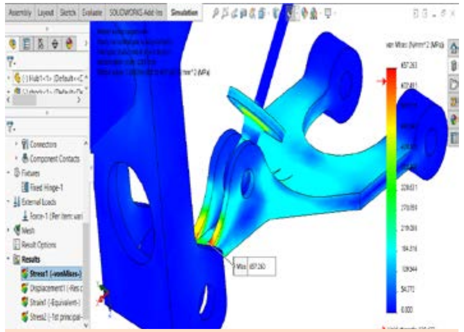
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Integrated Project												
3D Modelling			Materials and Component Selection			Analysis and Optimization			Prototype Development			Presentation Documentation



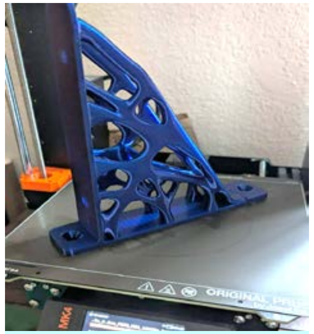
Produce CAD[@] files, drawings and BOM[#] of mechanical assemblies

[@] CAD: Computer Aided Design
[#] BOM: Bill Of Materials

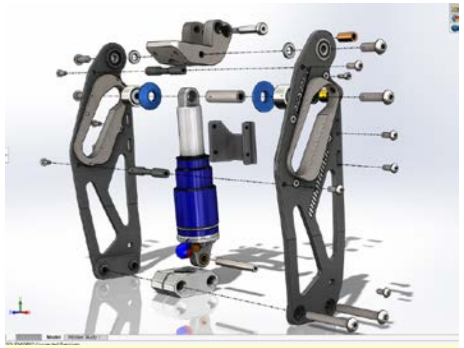
Perform design calculations and analysis on Machine Elements and Assembly



Perform stress and failure analysis of a multi-component engineering design



Carry out 3D printing of parts for prototyping



Present prototype(s) of design and technical details of the product, with documentation

- Only then are lesson plans (learning activities & course content) developed.

The End

Thank you