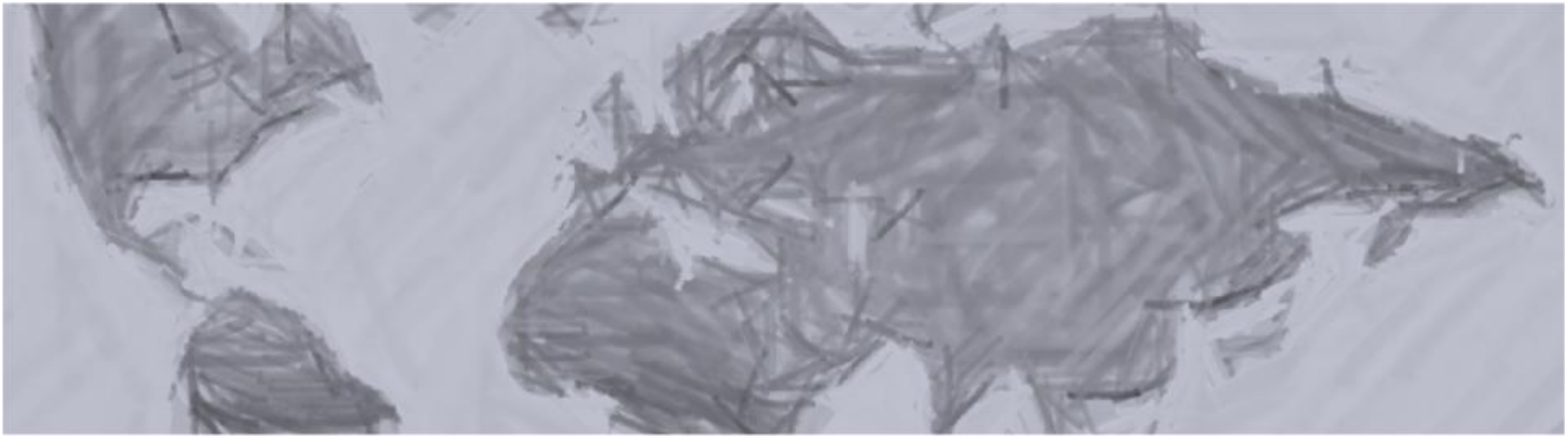
# *World Federation of Engineering Organisations (WFEO) Consultation Webinar with members of International Federation of Consulting Engineers (FIDIC)*

## *Overview of the Framework and proposed changes to Graduate Attributes (Table 4) of the IEA GAPC Framework*

***Dr. Marlene Kanga AM***
***WFEO President 2017-19***
***4 February 2021***



The World Federation of Engineering Organizations:

- The peak body for professional engineering organizations
- Founded in 1968
- Under the auspices of UNESCO
- 100+ national professional engineering institutions
- 12 international and continental/regional professional engineering institutions
- Representing 30 million engineers

# *Engineering* for Sustainable Development

Algeria
Argentina
Australia
Bahrain
Bangladesh
Belize
Bolivia
Brazil
Bulgaria
Cameroon
Canada
Chile
China
Chinese Taipei
Colombia
Costa Rica
Croatia
Cuba
Cyprus
Czech Republic
Ecuador
Egypt
Ethiopia
Fiji
France
Germany
Ghana
Greece
Honduras
Hong Kong, China
Hungary
India
Iraq
Italy
Ivory Coast
Japan
Jordan
Kenya
Korea
Kuwait
Lebanon
Libya
Macedonia (FYROM)
Madagascar
Malawi
Malaysia
Malta
Mauritius
Mexico
Moldavia
Mongolia
Montenegro
Morocco
Nepal
New Zealand
Nigeria
Pakistan
Palestine
Peru
Poland
Portugal
Puerto Rico
Qatar
Romania
Russia
Rwanda
Saudi Arabia
Senegal
Serbia
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Sudan
Switzerland
Syria
Tanzania
The Philippines
Tunisia
Turkey
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Yemen
Zambia
Zimbabwe

**Recognised NGO for engineering at UNESCO**

**Co-Chair of the Science and Technology Major Group at the UN**

**Representation at major UN Organisations**

**Based in Paris at UNESCO**

# Engineering and the UN Sustainable Development Goals


- **A key objective of the World Federation of Engineering Organizations is to advance the UN SDGs through engineering**
- **We need to ensure that we have more engineers with the right skills to develop the technologies and engineering solutions for sustainable development**

A key goal is to ensure that engineering graduates have the attributes and skills to meet current and future needs by employers, industry and the community and to work in partnership with peer organisations to meet this objective


# Partnering with our international peers

- This project has been progressed in partnership with our peer international organisations in engineering
- Together we are working on joint objectives in education, training and sustainable development
- Partnerships with:
  - International Engineering Alliance (IEA)
  - International Federation of Engineering Education Societies (IFEES)
  - Federation of International Consulting Engineers (FIDIC)
  - International Network for Women Engineers and Scientists (INWES)
  - International Centre for Engineering Education (ICEE, UNESCO Category II Centre) at Tsinghua University
  - International Science Technology and Innovation Centre for South-South Cooperation (ISTIC, Malaysia, UNESCO Category II Centre)

# The International Engineering Alliance (IEA) and the benchmark Framework for Graduate Attributes and Professional Competencies (GAPC)

- **IEA is an umbrella organisation that provides governance for the three Accords and four Agreements that provide international multilateral recognition of graduate attributes and professional competencies across 30 countries.**
- **For graduation after tertiary engineering education course:**
  - **Washington Accord – Professional Engineer 4-5 years**
  - **Sydney Accord – Engineering Technologist – 3-4 years**
  - **Dublin Accord – Engineering Technician -2 years**
- **After graduation for professional registration:**
  - **Intl. Professional Engr. Agreement – Prof. Engineer 4-5 years**
  - **Intl. Technologist Engr. Agreement – Eng. Technologist – 3-4 years**
  - **Intl. Associate Engr. Agreement – Eng. Technician -2 years**
  - **APEC Engineering Agreement – APEC Region- Prof. Engineer 4-5 years**

# The International Engineering Alliance (IEA) and the benchmark Framework for Graduate Attributes and Professional Competencies (GAPC) (2)

- **IEA has established a benchmark for expected graduate outcomes and professional competencies which are used by its signatories to establish substantial equivalence.**
- **WFEO has an MoU with the IEA and has established a Working Group with members from both organisations to review the benchmarks**




# Overview of review of the GAPC Framework by International Engineering Alliance (IEA) and World Federation of Engineering Organisations (WFEO)

1. **Objective of Review of Global benchmark - for engineering graduates outcomes – to reflect changes in societal needs and new thinking including:**
    - **UN Sustainable Development Goals**
    - **Diversity and Inclusion**
    - **Emerging technologies and disciplines in engineering**
    - **Rapidly changing technology environment and learning systems**
    - **Ethics**
    - **Lifelong learning**
2. **Objective of Review of Global benchmark - professional competencies – so graduates and engineering practitioners meet employer / employability needs/expectations including requirements for lifelong learning**
3. **WFEO members- to be consulted for feedback on proposed revised framework**
4. **WFEO partners – to be consulted for feedback on proposed framework: IFEES (Engineering education networks), FIDIC (Consulting engineering organisations), INWES (Women in engineering networks)**

# UNESCO is a key partner for the review of engineering benchmarks for Graduate Attributes and Professional Competencies

**The second UNESCO Engineering Report recommends:**

1. *"Government, engineering educators, industry and professional engineering institutions need to collaborate to increase the number and quality of engineers.*

2. *There is also a need to work in partnership to develop the necessary international engineering education benchmarks for sustainable development.*

3. *These need to be recognised across the world and form the basis of national engineering education systems for engineers with the right skills especially Asia, Africa and Latin America."*

# WFEO IEA Working Group for review of Graduate Attributes and Professional Competencies (GAPC)

- **Chair: IEA Nominated – Prof. Ari Bulent Ozguler MUDEK , Turkey**
- **IEA Members (all signatories)**
  - **Prof Mitsunori Makino and Ms Akiko Takahashi (JABEE), Japan**
  - **Prof Barry Clarke (Engineering Council UK) , UK**
  - **Ms Bernadette Foley (Engineers Australia), Australia**
- **WFEO Members –**
  - **Dr Marlene Kanga – WFEO President 2017-2019, Australia**
  - **Mr WANG Sunyu (Vice Director General, ICEE Tsinghua University), China**
  - **Prof. Dr Charlie Than, (President, Myanmar Engg. Council) , Myanmar**
  - **Dr Michael Milligan (Chief Executive, ABET) – representing IFEES, USA**

  **Others from ICEE China:**
  - **Mr KANG Jincheng, Strategic Specialist, ICEE**
  - **Mr QIAO Weifeng, Asst Professor Inst. Of Education Tsinghua University and ICEE**
  - **Mr XU Lihui, Research Associate, Inst. Of Education Tsinghua University and ICEE**
- **Schedule:**
- **Review current frameworks, draft discussion document for consultation Oct-2019 - June 2020**
- **Draft presented to IEA Annual meeting in June 2020**
- **Consultation: July 2020 – February 2021 (in progress)**
- **Revise and Finalise IEA Annual meeting June 2021 and WFEO General Assembly 2021**

# The IEA GAPC Benchmark: Context

- **GAPC are stated generically and are applicable to all engineering disciplines**
- ***Graduate attributes* form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The attributes are clear, succinct statements of the expected capability.**
- ***Professional competency profiles* record the elements of competency necessary for performance that the professional is expected to be able to demonstrate in a holistic way at the stage of attaining registration (i.e. 7 years after graduation).**

- **The graduate attributes identify the distinctive roles of *engineers, technologists and technicians***
- **The professional competency profiles are written for each of the three categories: *engineer, engineering technologist and engineering technician* at the point of registration**

# The IEA GAPC Benchmark review: Principles and Approach

**Recognize that GAPC Framework:**

- **Is not an "international standard" but provides a benchmark to judge substantial equivalence**
- **Is not prescriptive - reflects the essential elements**
- **Does not specify performance indicators for assessment of equivalence**
- **Applicable to all engineering disciplines, i.e. discipline-independent.**

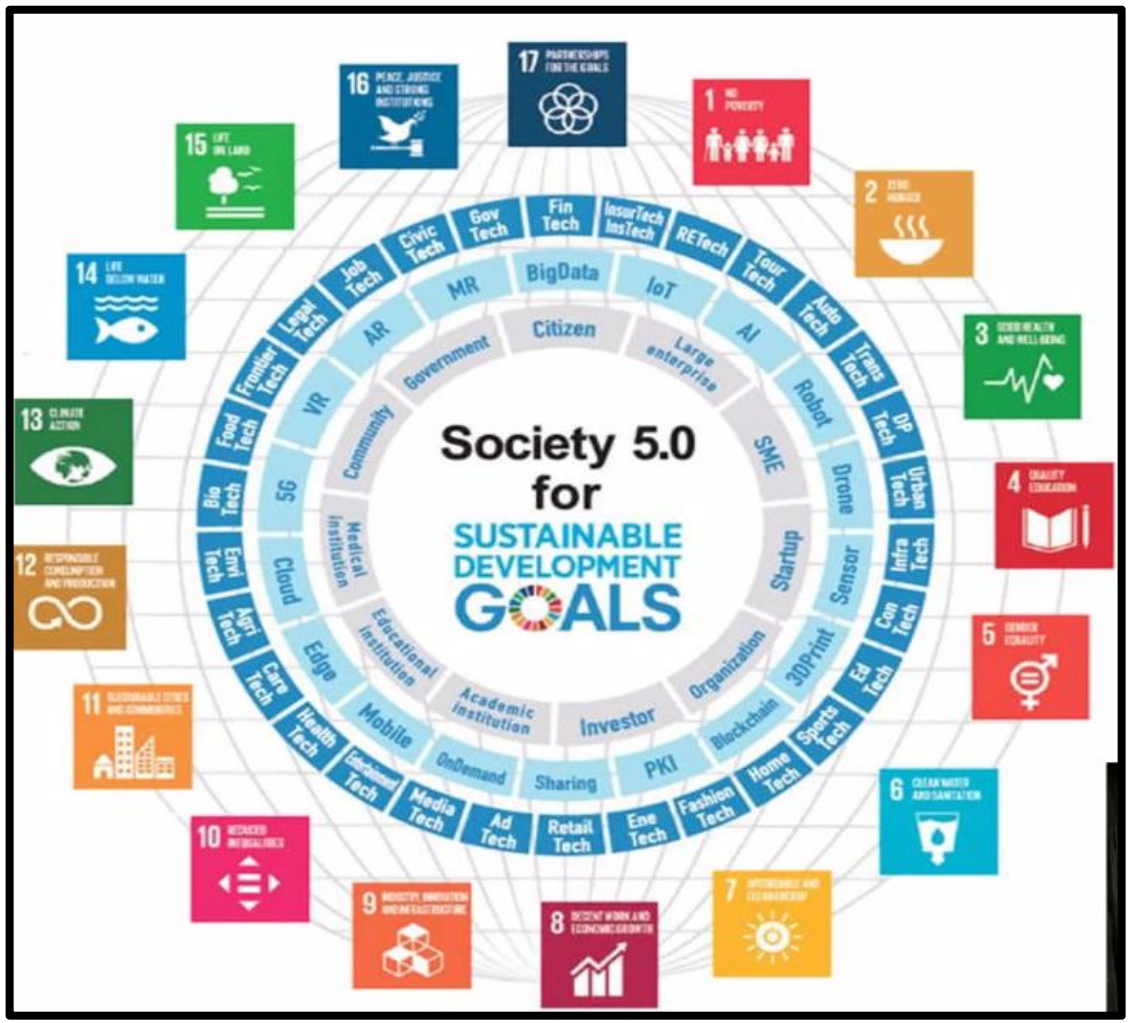
**<u>Approach</u>:**

- **Research current major reviews on engineering education globally**
- **Sought views from IEA signatories i.e Accreditation Agencies**
- **Focused on discipline-independent features**
- **Made sure that any modifications are "assessable" attributes/ competencies**
- **Maintained Framework structure, "no change" was as valid as a "change"**

# Emerging engineering disciplines and skills needed by engineers of the future

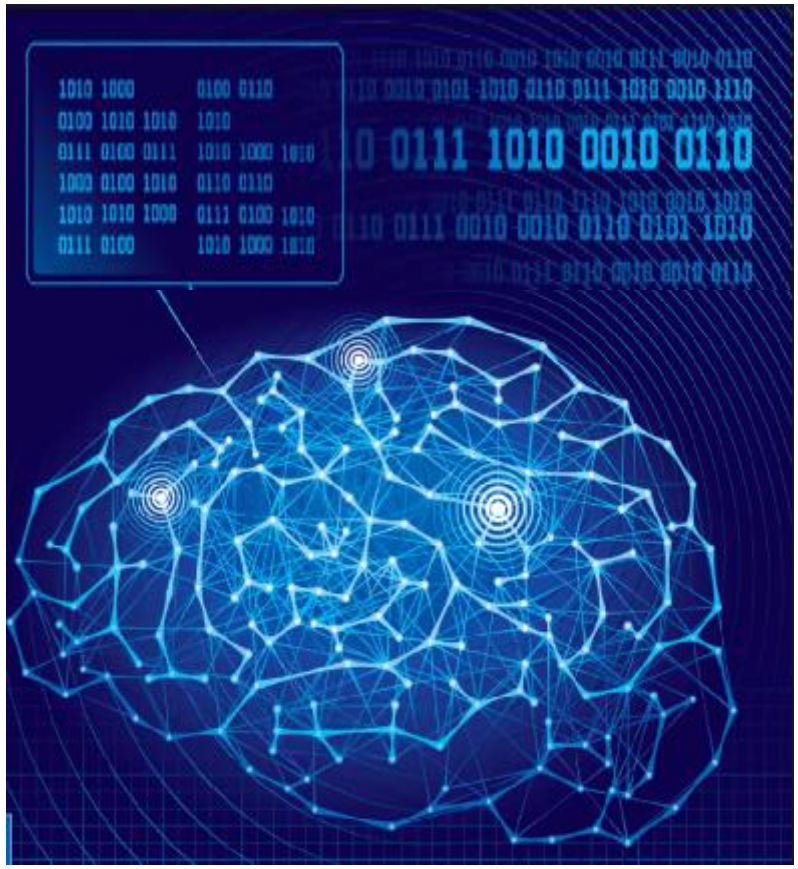
- **Core knowledge and skills, analytic background, knowledge specific to discipline, basic transferable skills will continue to be needed.**
- **IT skills, ability to write code, rely on 3D printing, digital skills (information literacy, media literacy, and information and communication technologies) will be core.**
- **Data driven analytics, digital proficiency, digital learning platforms**
- **`liberal arts training` become important**
- **Multi-disciplinary issues - social, legal, economic will need consideration in solutions**
- **The complexity (scale, diversity, globalism, disruptiveness) in engineering problems will increase - need for inclusive and sustainable solutions.**
- **Emphasis on `entrepreneurial skills`, `risk-taking`, and `critical thinking`**
- **Ability to work collaboratively with diverse teams, remote and virtual workplaces.**
- **Artificial Intelligence, Machine Learning, Automation, Human-Machine, and Machine-Machine interaction will have rapid growth**
- **And so on….**

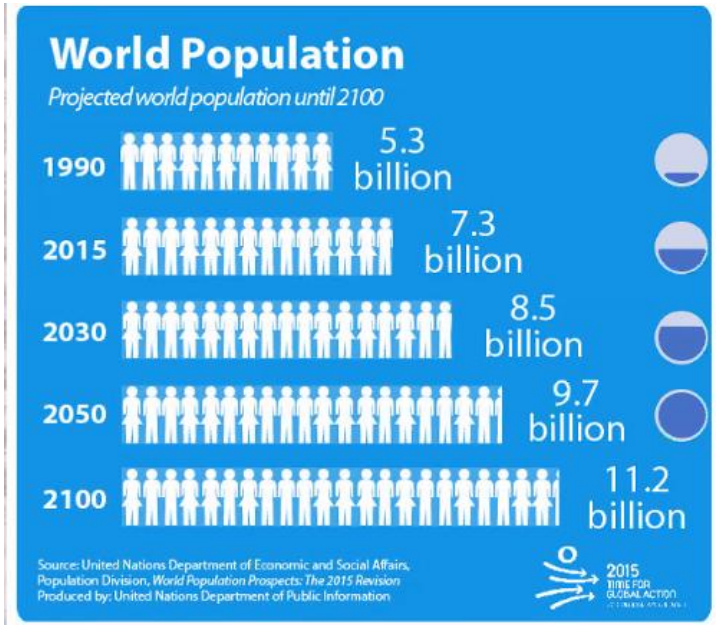
# Emerging engineering disciplines and technologies and the UN Sustainable Development Goals




Source: https://www.researchgate.net/figure/Society-50-for-sustainable-development-goals-4_fig1_336567060

# Increasing digitisation and information technologies is transforming our world




1990 GSM

2015 4G

2030 6G

2050 8G

Source: I. Opperman, Enabling our digital future, Feb. 2021

# Example – civil engineering - skills needed by engineers of the future

- **It is estimated that 90% of the work of civil engineers is embedded in the excellent codes and standards that underpin much of civil engineering. These can be used to build automated systems that may take over routine design work and tasks that once took many months of effort will be processed by a computer in a matter of hours.**
- **Building Information Modelling (BIM), Simulation, optimization, and automation are transforming engineering and artificial intelligence will be used for many tasks with little human intervention.**

# Civil and Construction Engineering : Disruptive technologies

- **Artificial Intelligence: using building codes for automated design**
- **Building Information Modelling (BIM): Design, project management, construction and maintenance**
- **3D Printing: Building models and services**
- **Cloud collaboration/Automation for teams: shared information on project plans, drawing, specifications, procurement**
- **Data: predictive analytics: construction, condition monitoring, maintenance**

# Engineering and digital transformation:

Regulations in NSW require all construction drawings to be in digital format from 1 July 2021.

# Engineering needs more brain power not muscle power

# Consultation with members of FIDIC

- **FIDIC, the International Federation of Consulting Engineers**, is the global representative body for national associations of consulting engineers and represents over one million engineering professionals and 40,000 firms in more than 100 countries worldwide.
- The member Associations of FIDIC are the employers of engineers around the world.
- This consultation webinar is **a key opportunity for employers to comment** on the graduate attributes and professional competencies of engineers to ensure that they have the right skills to make the contribution to their organizations.
- In the future, FIDIC may play a part with WFEO in **Capacity Building** and training of engineers and development of professional competencies that align with the benchmarks of the International Engineering Alliance
- **Young engineers** in particular will be impacted by the proposed changes as they develop their careers in a rapidly changing technology environment

# Key focus areas for change

1. **Accommodate future needs** of engineering professionals and the profession – strengthen the required attributes on team work, communication, ethics, sustainability.
2. **Emerging technologies** – incorporate digital learning, active work experience, lifelong learning.
3. **Emerging and future engineering disciplines and practice areas** – while retaining discipline independent approach, enhance the skills on data sciences, other sciences, life-long learning.
4. **Incorporate UN Sustainable Goals** - in the development of solutions that consider diverse impacts – technical, environment, social, cultural, economic, financial and global responsibility
5. **Diversity and Inclusion** – include these considerations within ways of working in teams, communication, compliance, environment, legal etc. systems.
6. **Intellectual agility, creativity and innovation** – emphasize critical thinking and innovative processes in design and development of solutions

# Structure of GAPC Framework

**The GAPC Comprises five tables:**

1. **Table 1: Range of Problem Solving Capabilities** that distinguish the 4-5-year programs with engineer graduates from those that have a teaching duration of 3-4 years for technologists or 2 years for graduating technicians. Distinguishes between complex, broadly-defined and well-defined engineering problems.
2. **Table 2: Range of Engineering Activities** for an engineer, a technologist, and a technician, respectively.
3. **Table 3: Knowledge and Attitude Profile** of a graduate of an engineering program, i.e. the minimum requirements for the curriculum
4. **Table 4: Graduate Attribute Profiles the qualifications** (assimilated knowledge, skills, and attitudes) of an engineer/technologist/technician at the time of graduation.
5. **Table 5: Professional Competency Profiles** specifies the range of competency profiles for a qualified engineer/technologist/technician. These need to be attained, not only during school education but also, through lifelong learning and professional development to practice at an appropriate level.




# Table 4: Graduate Attribute Profile

- **Graduate Attribute Profile - the qualifications (assimilated knowledge, skills, and attitudes) of a professional engineer/technologist (3-4 year)/technician (2-3 year) are described.**
- **In this presentation - focus is on the professional engineer – 4-5 year degree.**
- **Attributes for technologists and technicians are described in the full Framework which is available on the WFEO website https://bit.ly/3fg8Fdh**
- **Proposed changes are as at July 2020. Further changes are being made as a result of the consultation process.**

# GAPC Table 4: Graduate Attribute Profile

**Graduate attributes cover:**

1. Engineering knowledge
2. Problem analysis
3. Design and development of solutions
4. Investigation and research
5. Usage of appropriate tools

KNOWLEDGE

6. The engineer and society
7. Human, social and environmental impacts
8. Ethics

ENGINEER & SOCIETY

9. Individual and collaborative team work
10. Communication
11. Project Management and Finance
12. Preparation for lifelong learning

WAYS TO WORK

# GAPC Table 4: Graduate Attributes – (1)

| Differentiating Characteristics | … for Professional Engineeer Graduate | Reason for change |
|---|---|---|
| Engineering Knowledge | WA1: Apply knowledge of mathematics, natural science, computing and engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop the solution of complex engineering problems. | The graduate is expe the necessary skills i addition to knowled natural science and fundamentals. |
| Problem Analysis - Complexity of analysis | WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusion mathematics, natural sci sciences with holistic co sustainable developmen | The graduate is est thinking a e implicatio velopment |
| Design/ development of solutions: Breadth and uniqueness of engineering problems i.e. the extent to which problems are original and to where solutions have not previously been identified or codified | WA3: Design solutions for co plex engineering problems and design systems, components or processes that meet identified ~~specified~~ needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon, resource, cultural, societal, and environmental considerations. (WK5) | A graduate is expecte to consider the whole of life cost and net zero carbon of solutions from cradle to cradle. |

BASICS + COMPUTING SKILLS

LATEST THINKING, CONSIDER IMPACTS FOR SUSTAINABLE DEVELOPMENT

CREATIVITY, INNOVATION, CRITICAL THINKING,

DESIGN SOLUTIONS SHOULD CONSIDER WHOLE OF LIFE COST, ZERO CARBON IMPACTS

# GAPC Table 4: Graduate Attributes (2)

| Differentiating Characteristics | … for Professional Engineeer Graduate | Reason for c |
|---|---|---|
| **Investigation**: Breadth and depth of investigation and experimentation | WA4: Conduct investigations of complex problems and systems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions | |
| ~~**Modern Digital**~~ **Tool Usage:** Level of understanding of the appropriateness of technologies and ~~various~~ tools | WA5: Create, select and apply appropriate techniques, including prediction and modelling, computing and information tools, and data analytics ~~and modern engineering and IT tools, including prediction and modelling~~, to complex engineering problems, with an understanding of the limitations. (WK6) | The graduate is **modelling and techniques** to s solutions while implications of a limitations of th |
| **The Engineer and Society:** Level of knowledge and respoonsibility | WA6: Apply reasoning within sound decision making frameworks that are informed by contextual knowledge and stakeholder consultation to assess societal, health, safety, legal, historical and cultural issues and the consequent responsibilities for sustainable development relevant to professional engineering practice and solutions to complex engineering problems. (WK7) | The ability to **consult with stakeholders** from a wide cross-section of society and consider a range of requirements, has been added. |

USE IF DATA AND MODELLING AND COMPUTATIONAL TOOLS

SOCIAL LICENSE TO PRACTICE – STAKEHOLDER CONSULTATION

# GAPC Table 4: Graduate Attributes (3)

CONSIDER HUMAN SOCIAL ECONOMIC AND ENVIRONMENTAL IMPACTS

ETHICS – BROADLY – TECHNOLOGY, DATA, HUMAN, COMPLY WITH LAWS,

WORKING COLLABORATIVELY IN DIVERSE TEAMS IN THE BROADEST SENSE

| Differentiating Characteristics | … for Professional Engineeer Graduate | Reas |
|---|---|---|
| Human, Social, Economic and Environmental impacts ~~and type of solutions~~ | WA7: Understand and evaluate the sustainability ~~and~~ impact of professional engineering work in the solution of complex engineering problems in human, cultural, economic, social ~~etal~~ and environmental contexts. (WK7) | |
| **Ethics:** Understanding and level of practice | WA8: Apply ethical principles and commit to professional ethics, technology ethics, data ethics, global responsibilities, ~~and responsibilities~~ and norms of engineering practice; and adhere to relevant national and international laws. Comprehend the need for diversity and inclusion (WK9) (WK7) | added |
| Individual and Collaborative Team work: Role in and diversity of team | WA9: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multi-disciplinary and long-distance settings. | The importance of working effectively in diverse teams by ethnicity, gender, age, location etc. has been added |

# GAPC Table 4: Graduate Attributes (4)

| Differentiating Characteristics | … for Professional Engineeer Gra | |
|---|---|---|
| **Communication:** Level of communication according to type of activities performed | WA10: Communicate effectively and on complex engineering activities wit engineering community and with society at large, such as being able to comprehend, write and present in a variety of ways effectively considering cultural, language and learning differences ~~reports and design documentation, make effective presentations, and give and receive clear instructions.~~ | The importance of **inclusive communication**, written and verbal, taking account of cultural, language and other differences, has been added |
| **Project Management and Finance:** Level of management required for differing types of activity | WA11: Demonstrate knowledge and understanding of engineering managemer principles and economic decision-making apply these to one's own work, as a mem leader in a team, to manage projects and multidisciplinary environments. | |
| **Continual Lifelong learning:** Preparation for and depth of continuing learning. | WA12: Recognize the need for, and have the preparation and ability to engage in i) independent and life-long learning ii) creativity and) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK9) | The importance of **creativity, critical thinking and lifelong learning**, has been added |

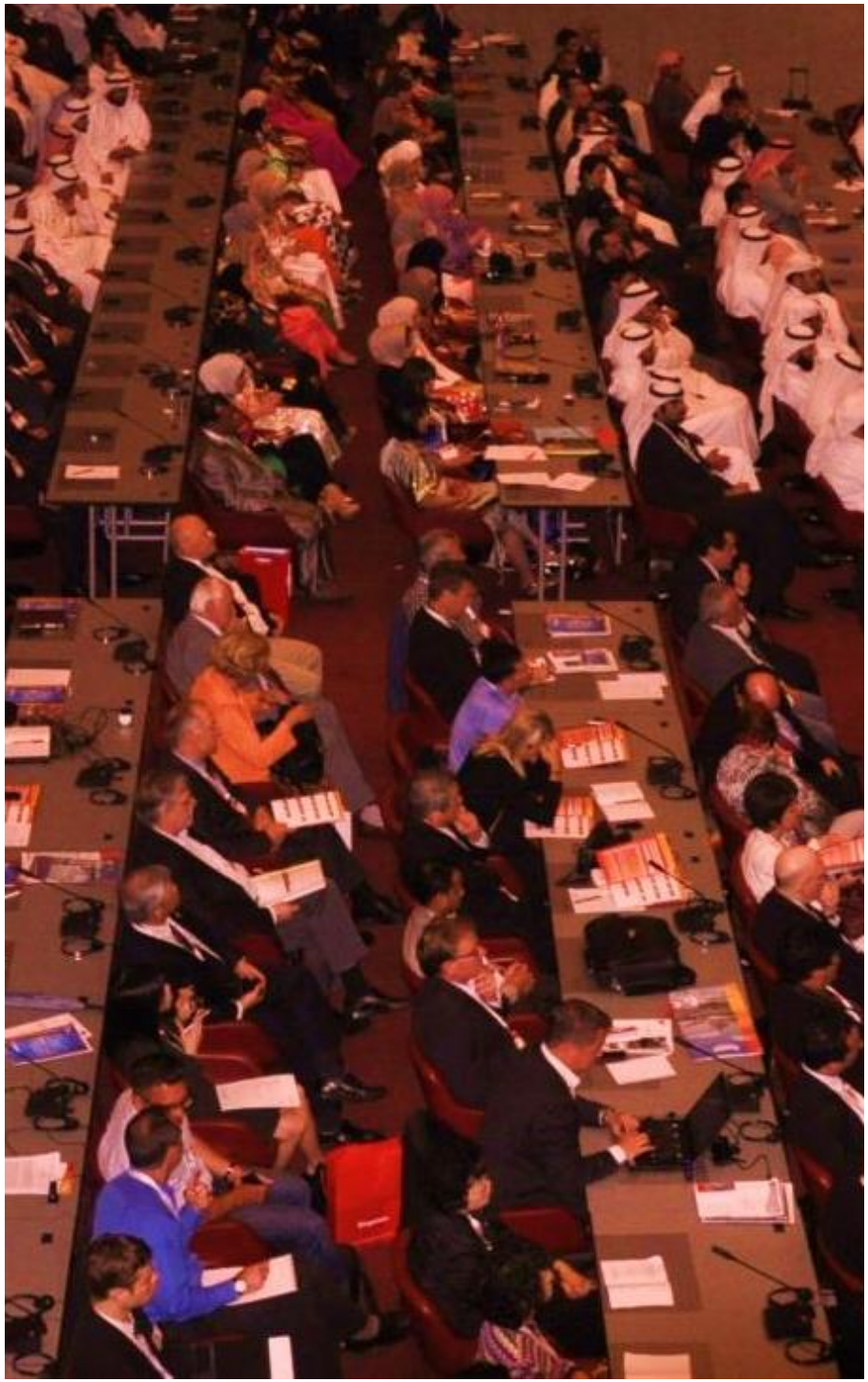
INCLUSIVE COMMUNICATION – LANGUAGE, CULTURE, LEARNING DIFFERENCES

CREATIVITY, INNOVATION, CRITICAL THINKING,

ADAPT TO NEW AND EMERGING TECHNOLOGIES

# Please provide your feedback

- **The entire table "A Proposal to Update the GAPC Tables.docx" is available at : https://bit.ly/3fg8Fdh**
- **The document contains the five tables relating to graduate attributes and professional competencies for the professional engineer, the technologist and technicians with changes (deletions and additions) on the present GAPC Framework.**
- **In order to add your comments, use the same file "A Proposal to Update the GAPC Tables.docx" and the tables therein, and insert or delete your suggestions of changes in the relevant cell using a new font color. Insert your explanatory notes, if any, in the last column.**
- **Please return the file, after an extension of the filename with your name or your institution's name, as appropriate, to secretariat@wfeo.org.**
- **A brief survey will be sent out as an alternative way of providing your feedback. This will take less than 5 minutes to complete**
- **Please send your feedback no later than 15 February 2021.**



## *Engineering* for Sustainable Development

- Participation
- Influence
- Representation

**The world's engineers united in rising to the world's challenges. For a better, sustainable world.**

WFEO / FMOI

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

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