World Federation of Engineering Organisations (WFEO) Consultation Webinar

Overview of the IEA GAPC Framework and proposed changes with emphasis on Diversity and Inclusion

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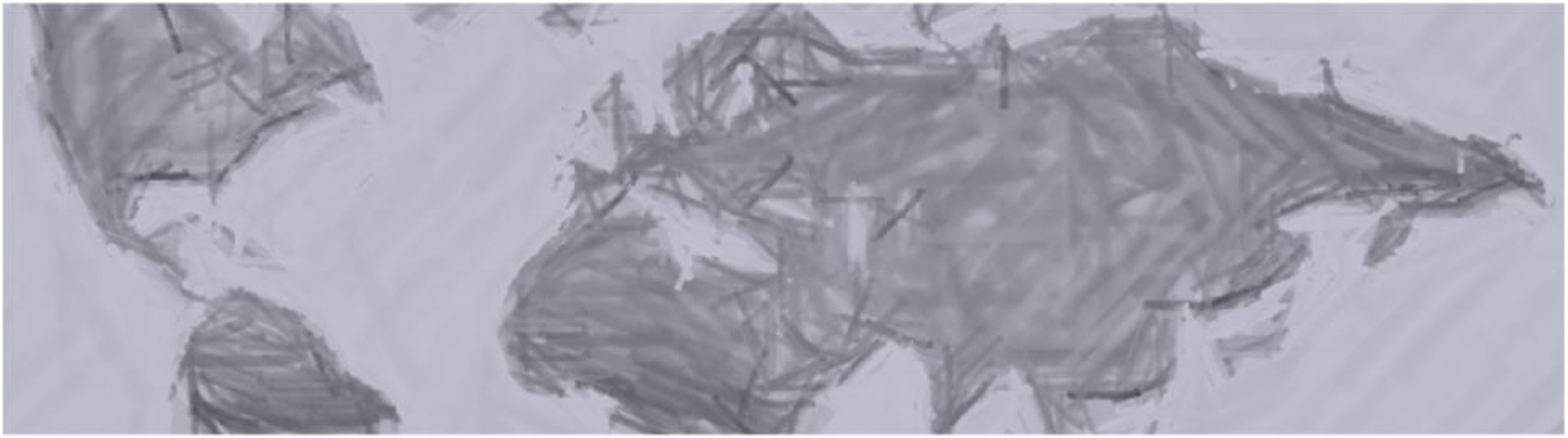
WFEO President 2017-19
31 July 2020



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

Founded under the auspices of UNESCO and Recognised NGO

Co-Chair - Major Science and Technology Group at 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

***Engineering* 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

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, China**
  - **International Science Technology and Innovation Centre for South-South Cooperation (ISTIC, Malaysia, UNESCO Category II Centre)**

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

The second UNESCO Engineering Report – "Engineering for the SDGs" 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."*

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 usually 4-5 years**
  - **Sydney Accord – Engineering Technologist usually – 3-4 years**
  - **Dublin Accord – Engineering Technician usually -2 years**
- **After graduation for professional registration, after a period of work experience:**
  - **Intl. Professional Engr. Agreement – Prof. Engineer**
  - **Intl. Technologist Engr. Agreement – Eng. Technologist**
  - **Intl. Associate Engr. Agreement – Eng. Technician**
  - **APEC Engineering Agreement – APEC Region- Prof. Engineer**

* Note: The duration of academic formation will normally be at least sixteen years (Washington Accord), fifteen years (Sydney Accord) and 13 years (Dublin Accord).

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

1. **Review Global benchmark - for engineering graduates outcomes:**
    - **UN Sustainable Development Goals**
    - **Diversity and Inclusion**
    - **Emerging technologies and disciplines in engineering**
    - **Rapidly changing technology environment and learning systems**
2. **Review Global benchmarks - 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 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 WFEO IEA Working Group for review of Graduate Attributes and Professional Competencies (GAPC)

- **Chair**: IEA Nominated – Prof. Arif 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
- **Co-Chair** – WFEO Nominated
- **WFEO Members** –
  - Dr Marlene Kanga – WFEO President 2017-2019, Australia
  - Mr WANG Sunyu (Vice Director General, ICEE Tsinghua University), China
  - 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, prepared by the Working Group, for consultation Nov-2019 - June 2020 (Available on the consultation web page)
- Consultation: July 2020 – Dec 2020
- 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 competent performance that the professional is expected to be able to demonstrate in a holistic way at the stage of attaining registration.

- 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: 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….**

Recognition of the need for change

- A great deal of progress has been made by UNESCO WFEO IEA Working Group
- These change include attention to the use of information technologies, data and analytics
- The ability to learn and adapt to new and emerging technologies
- Greater responsibility to society and the environment
- incorporating the need to address the objectives of the UN Sustainable Development Goals
- Embedding cultures, behaviours and values for a more diverse and inclusive profession
- A broad ethical approach and responsibility for the development of engineering solutions.
- The need for on-line communication and consultations, highlighted during COVID-19 lockdowns
- Global acceptance has been remarkably fast, demonstrating that the profession itself has recognised the need for urgent change to maintain the social license for relevant, contemporary engineering solutions.

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 civil engineering and will be used for many tasks with little human intervention.**

Engineering needs more brain power not muscle power

Source: www.UNOPS.org

Source: www.esri.com

Key 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 **AND LEAVE NO ONE BEHIND**
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. **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. **Range of Engineering Activities** for an engineer, a technologist, and a technician, respectively.
3. **Knowledge and Attitude Profile** of a graduate of an engineering program, i.e. the minimum requirements for the curriculum
4. **Graduate Attribute Profiles the qualifications** (assimilated knowledge, skills, and attitudes) of an engineer/technologist/technician at the time of graduation.
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 and 5: Graduate Attribute and Professional Competency Profile

- **Table 4: Graduate Attribute Profile - the qualifications (assimilated knowledge, skills, and attitudes) of a professional engineer/technologist (3-4 year)/technician (2-3 year) are described.**
- **Table 5: Professional Competency Profiles specifies the range of competency profiles for a qualified engineer/technologist/technician.**
- **In this presentation - focus is on the professional engineer – usually 4-5 year degree.**
- **Attributes for technologists and technicians are described in the full in the Report by the UNESCO WFEO IEA Working Group which is available on the WFEO website https://bit.ly/3fg8Fdh**

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 expected to also develop the necessary skills **in computing** addition to knowledge of mathematics, natural science and engineering fundamentals.
Problem Analysis - Complexity of analysis	WA2: Identify, formulate, research literature and analyse 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)	The graduate is expected to apply the latest thinking and holistically consider the **implications for sustainable development**
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 complex 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 expected to consider the **whole of life cost** and net zero carbon of solutions from cradle to cradle.

GAPC Table 4: Graduate Attributes (2)

Differentiating Characteristics	… for Professional Engineeer Graduate	Reason for change
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 expected to use **data, modelling and computational techniques** to simulate possible solutions while understanding the implications of assumptions made and limitations of the data being used.
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.

GAPC Table 4: Graduate Attributes (3)

Differentiating Characteristics	… for Professional Engineeer Graduate	Reason for change
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)	The ability to evaluate the **impact of engineering solutions on people, the economy and the environment** has been added
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)	The importance of the **responsible use of data** in engineering solutions, ethical responsibilities for compliance with national and international law has been 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 Graduate	Reason for change
Communication: Level of communication according to type of activities performed	WA10: Communicate effectively and inclusively on complex engineering activities with the 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 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.	
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

GAPC Table 5: Professional Competencies Profile

Required Professional Competencies include cover:

1. Apply universal knowledge
2. Apply local knowledge
3. Problem analysis
4. Design and development of solutions
5. Evaluation of solutions

KNOWLEDGE

6. Protection of society
7. Legal, environmental, cultural and regulatory impacts
8. Ethics, Diversity and Inclusion

ENGINEER & SOCIETY

9. Manage engineering activities
10. Communication and collaboration
11. Continual professional development, lifelong learning
12. Exercise judgement
13. Responsibility for decisions

WAYS TO WORK

GAPC Table 5: Professional Competencies (1)

Differentiating Characteristic	Professional Engineer	Reason for Change
Comprehend and apply universal knowledge: Breadth and depth of education and type of knowledge	**EC1:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice	
Comprehend and apply local knowledge: ~~–~~Type of local knowledge	**EC2:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction of ~~in which he/she~~ practice.	Gender neutral language used.
Problem analysis: Complexity of analysis	**EC3:** Define, investigate and analyse complex problems using data and information technologies	The use of computing and IT tools has been added.
Design and development of solutions: Nature of the problem and uniqueness of the solution	**EC4:** Design or develop inclusive solutions to complex problems with stakeholder consultation	The importance of inclusive solutions and stakeholder consultation has been added.
Evaluation: Type of activity	**EC5:** Evaluate the outcomes and impacts of complex activities in the contexts of risk and social, environmental, economic and resource impacts	The importance of evaluation and risk assessment in broad contexts has been added

GAPC Table 5: Professional Competencies (2)

Differentiating Characteristic	Professional Engineer	Reason for Change
Protection of society: Types of activity and responsibility to consider advancement of the UN Sustainable Development Goals ~~public~~	**EC6:** Recognise the reasonably foreseeable social, cultural and environmental effects of complex activities generally, and have regard to the need for sustainable outcomes that leave no one behind per the UN Sustainable Development Goals; global quality of life for humans and the environment. ~~ility~~; ~~recognise that the protection of society is the highest priority~~	The importance of consideration of the advancement of the UN Sustainable Development Goals where relevant has been added
Legal, environment, cultural and regulatory: No differentiation in this characteristic	**EC7:** Meet all legal and regulatory Requirements, protect public health and safety, environment and cultural heritage in the course of all ~~his or her~~ activities	The importance of compliance with relevant laws and regulations including to protect the **environment and cultural heritage** and gender neutral language has been added
Ethics, Diversity, and Inclusion: ~~No differentiation in this characteristic~~ Types of activity and attitude	**EC8:** Conduct ~~his or her~~ all activities ethically and inclusively, respecting cultural, ethnic, religious and all other differences	The ethics of equal opportunity for all through working effectively in diverse and inclusive teams and gender neutral language has been added

GAPC Table 5: Professional Competencies (3)

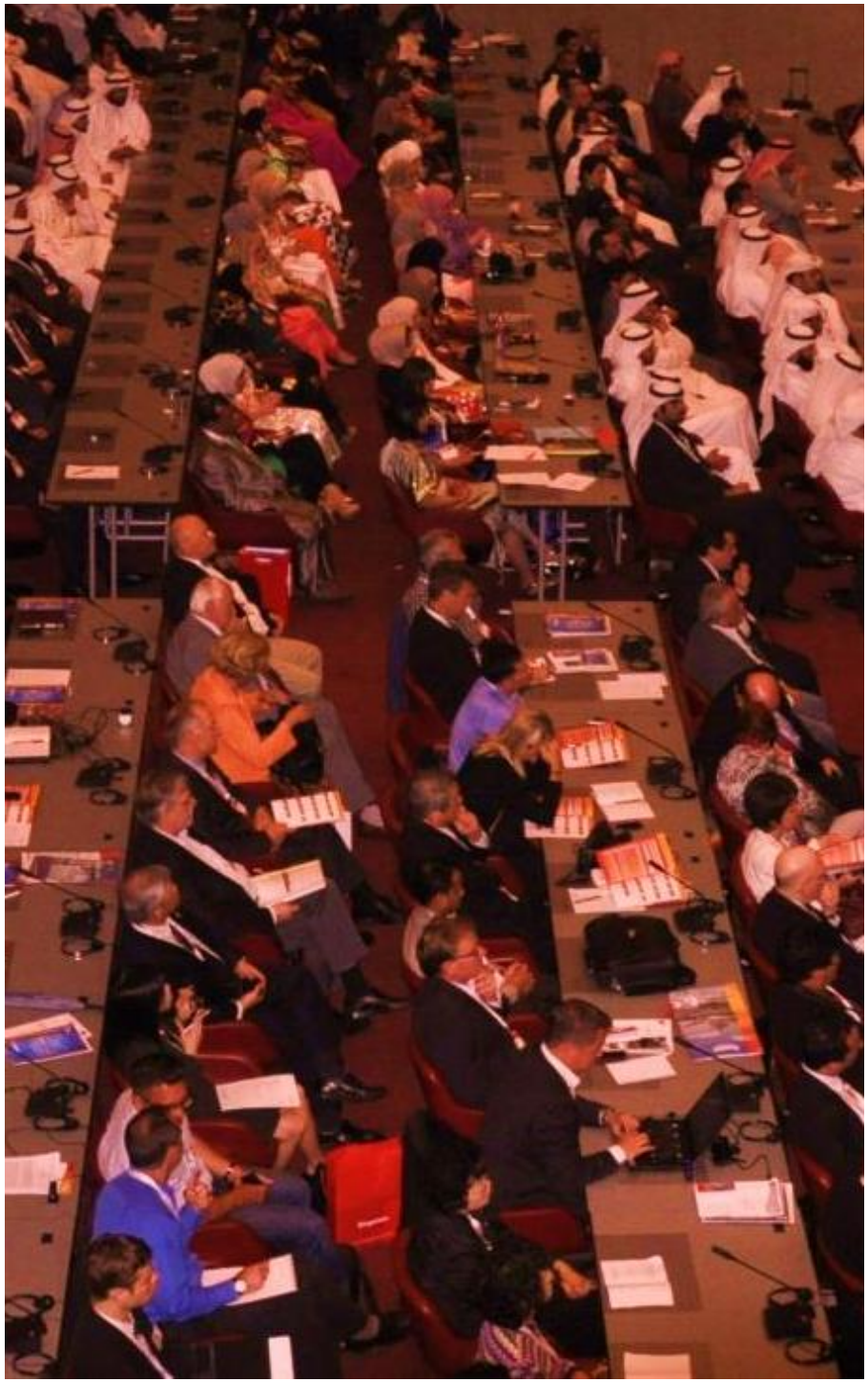
Differentiating Characteristic	Professional Engineer	Reason for Change
Manage engineering activities: Types of activity	EC9: Manage part or all of one or more complex activities	
Communication and Collaboration: Requirement for inclusive communications, No differentiation in this characteristic	EC10: Communicate and collaborate using multiple mediums clearly and inclusively with a broad range of stakeholders in the course of ~~his or her~~ all activities	The importance of inclusive communications and gender neutral language has been added
Continuing Professional Development (CPD):~~Lifelong learning:~~ Preparation for and depth of continuing learning.	EC11: Undertake CPD activities sufficient to maintain and extend technical competencies and enhance their ability to adapt to emerging technologies and the ever changing nature of work. ~~sufficient to maintain and extend his or her competencies~~	The importance of lifelong learning in a world of rapidly changing technologies and gender neutral language has been added

GAPC Table 5: Professional Competencies (4)

Differentiating Characteristic	Professional Engineer	Reason for Change
Judgement: Level of developed knowledge, and ability and judgement in relation to type of activity	**EC12:** Recognize complexity and assess alternatives in light of competing social, economic, environmental, cultural and other requirements and considering incomplete knowledge. Exercise sound judgement in the course of all ~~his or her~~ complex activities	The need to exercise judgement and application of knowledge and ability in broad context and gender neutral language has been added
Responsibility for decisions: Type of activity for which responsibility is taken	**EC13:** Be responsible for making decisions on part or all of complex activities	

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.**
- **Please send your feedback no later than 31 August 2020.**



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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