



WFEO / FMOI



ACE 2020 International
Accreditation Conference in Engineering
November 17-19, 2020
Manila, Philippines

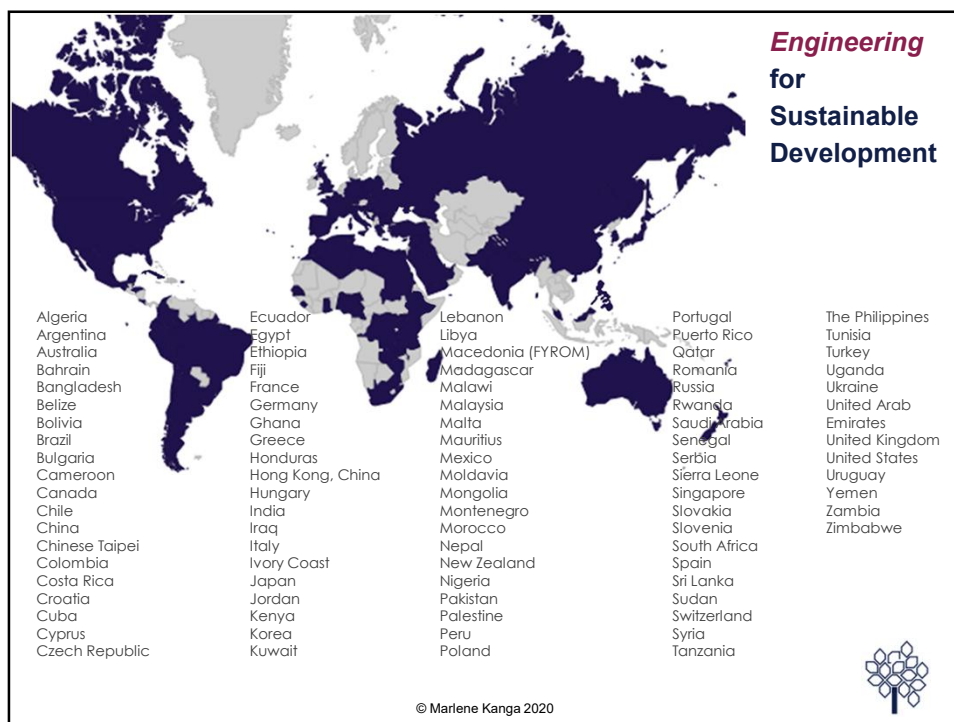


The World Federation of Engineering Organizations:

- 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

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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

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Engineering 2030 – Vision presented by Dr Marlene Kanga as incoming WFEO President at WFEO GA 2017

1. **Encourage young people** – To consider engineering as a career
2. **Graduate Outcomes** - Agree with educators, government, industry
3. **Global standards** - for engineering education and professional development
4. **Partnerships** – with international standard setting organisations for consistent international framework
5. **Support** – development of national engineering education systems to comply with agreed standards
6. **Capacity Building** – for accreditation of engineering education and accreditation bodies
7. **Capacity Building** – for professional engineering institutions
8. **Develop professional competency pathways** – so graduates meet employer needs
9. **Support national and international registration** – for recognition of qualifications and experienced of practising engineers
10. **Liaise with governments** – to establish consistent regulation policies for engineers
11. **Establish an international platform for engineering standards** – Education and professional development, under auspices of WFEO and UNESCO
12. **Report on progress** - to UNESCO and other international organisations

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Engineering 2030 – Principles for Action

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Engineering for Sustainable

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 our national and international members and peer organisations to meet this objective



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UNESCO WFEO IEA Plenary on Engineering Education @ WEC2019 – Declaration committing to working together

1. Recognise the Current IEA Graduate Attributes and Professional Competencies Framework as international engineering benchmark standards;
2. Support IEA review of the IEA Graduate Attributes and Professional Competencies to ensure that they meet the requirements for new technologies and engineering disciplines, new pedagogies and include contemporary values such as sustainable development, diversity and inclusion and ethics;
3. Extend the global reach of the IEA Agreements and Accords through capacity building efforts, such as mentoring and training, that support the development of engineering accreditation and professional competence/registration/licensure systems, appropriate to each jurisdiction;
4. Support the development of professional engineering institutions through capacity building efforts to ensure engineering quality and standards are maintained;
5. Support the development of national, regional and international registers and liaise with governments for the regulation of engineers to ensure their competence, performance, integrity and accountability throughout their careers, and
6. Facilitate the international mobility of engineers.

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UNESCO WFEO IEA Plenary on Engineering Education @ WEC2019 – Declaration committing to working together

Signing of MoU between IEA and WFEO, WEC2019, Melbourne



Dr Peggy Oti-Boateng, Director, Capacity Building Section, Natural Sciences Sector UNESCO, speaks at Plenary, WEC2019, Melbourne

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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."*



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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)

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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

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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
 - Representatives of IEA Signatories
 - Representatives of WFEO Members
- This project is part of **Working Group 1**
- **Working Group 2** is for capacity building in engineering to achieve IEA Signatory status and is led by the WFEO Standing Technical Committee on Education in Engineering, chaired by Prof. Dr Charlie Than President Myanmar Engineering Council, member of the working group include representatives from IEA signatories, FEIAP, FAEO and other regions seeking support.

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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
- Critical thinking, innovation, assessment of outcomes

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- consulted for feedback on proposed revised framework

4. WFEO partners – consulted for feedback on proposed framework: IFEEES (Engineering education networks), FIDIC (Consulting engineering organisations), INWES (Women in engineering networks), Young engineers groups

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WFEO IEA Working Group #1 – 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 IFEEES, 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 – Dec 2020 (in progress)
- Revise and Finalise IEA Annual meeting June 2021 and WFEO General Assembly 2021

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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

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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.

Approach:

- 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"

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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....

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



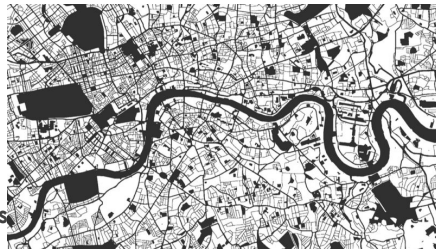
- It is estimated that 90% of the work of civil engineers is embedded in the excellent codes and standards that underpin much of civil engineering. These can be used to build automated systems that may take over routine design work and tasks that once took many months of effort will be processed by a 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.

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Civil and Construction Engineering : Disruptive technologies

- **Artificial Intelligence:** using building codes for automated design
- **Building Information Management (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
- **Energy: Kinetic Roadways – harnessing the energy of vibration**
- **PV Glazing/Tiles:** using passive structures for energy generation



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Engineering and digital transformation:

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



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Engineering needs more brain power not muscle power



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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



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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.

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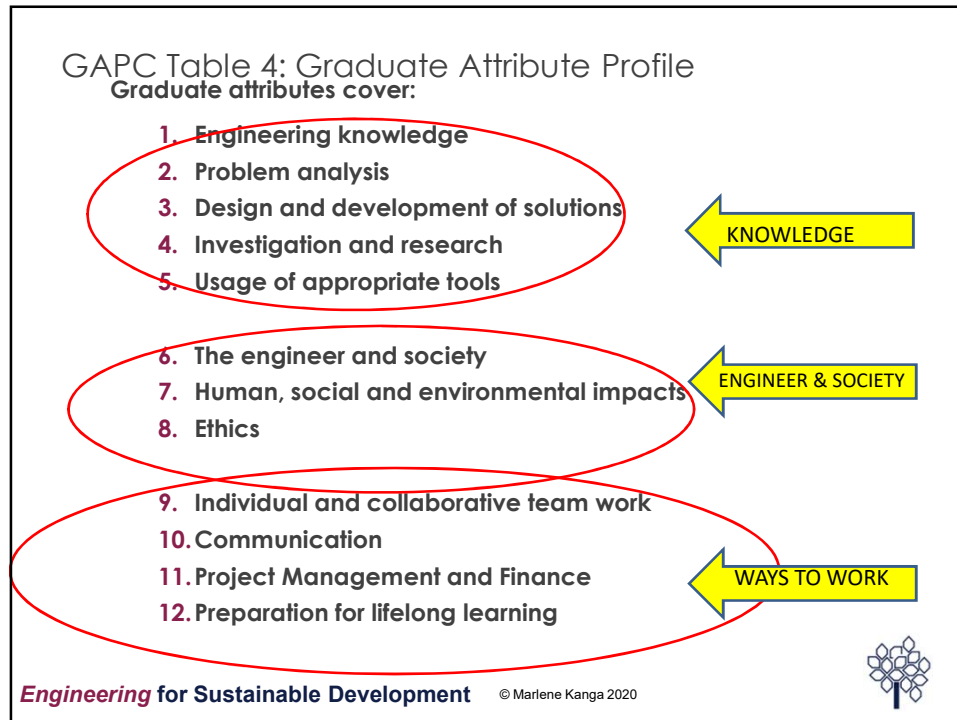


Table 4: Graduate Attribute Profile

- **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.
 - Changes are as at July 2020, further changes to be made after all feedback has been received and reviewed – **this is a work in progress**
- Attributes for technologists and technicians are described in the full Framework which is available on the WFEO website <https://bit.ly/3fq8Fdh>

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GAPC Table 4: Graduate Attributes – (1)

Differentiating Characteristics	... for Professional Engineer Graduate	Reason for change	BASICS + COMPUTING SKILLS
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 have the necessary skills in addition to knowledge of natural science and fundamentals.	LATEST THINKING, CONSIDER IMPACTS FOR SUSTAINABLE DEVELOPMENT
Problem Analysis - Complexity of analysis	WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusion in mathematics, natural sciences with holistic consideration of sustainable development	The graduate is expected to have the latest thinking and the implications of development	DESIGN SOLUTIONS SHOULD CONSIDER WHOLE OF LIFE COST, ZERO CARBON IMPACTS
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.	

CREATIVITY, INNOVATION, CRITICAL THINKING,

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GAPC Table 4: Graduate Attributes (2)

Differentiating Characteristics	... for Professional Engineer 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 solutions while implications of limitations of th
The Engineer and Society: Level of knowledge and responsibility	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

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GAPC Table 4: Graduate Attributes (3)

Differentiating Characteristics	... for Professional Engineer Graduate	Reason for c
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 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)	
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.	

CONSIDER HUMAN SOCIAL ECONOMIC AND ENVIRONMENTAL IMPACTS

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

WORKING COLLABORATIVELY IN DIVERSE TEAMS IN THE BROADEST SENSE

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GAPC Table 4: Graduate Attributes (4)

Differentiating Characteristics	... for Professional Engineer Gra	INCLUSIVE COMMUNICATION – LANGUAGE, CULTURE, LEARNING DIFFERENCES
Communication: Level of communication according to type of activities performed	WA10: Communicate effectively and 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 apply these to one's own work, as a member leader in a team, to manage projects and multidisciplinary environments.	CREATIVITY, INNOVATION, CRITICAL THINKING, ADAPT TO NEW AND EMERGING TECHNOLOGIES
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

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Consultation to date on Graduate Attributes and Professional Competencies (GAPC) Framework

- 3 webinars – 751 attending
- Survey – responses from every continent
- Detailed submissions, more than 15, every continent

Continent	No.
Africa	65
Asia	525
Americas	92
Europe	38
Middle East	20
Oceania	11
Total	751

See: <http://www.wfeo.org/consultation-with-wfeo-members-and-partners-on-proposed-updated-iea-benchmark-for-graduate-attributes-and-professional-competencies/>

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Feedback received has been overwhelmingly positive

“The GAPC framework is truly transformative in outlook for engineering education, and of major importance.”

Professor Tim Ibell FEng
 Professor of Structural Engineering
 Associate Dean of the Faculty of Engineering and Design
 BRE Centre for Innovative Construction Materials
 Department of Architecture and Civil Engineering
 University of Bath
 Bath
 BA2 7AY
 United Kingdom

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Feedback received has been overwhelmingly positive and constructive

1. University of Western Australia
2. American Society of Civil Engineers, ASCE Body of Knowledge Version 3 (BOK3)
3. South African Institution of Civil Engineers
4. International Network for Women Engineers and Scientists (INWES)
5. University of Bath, UK
6. Civil Engineering Specialist Advisory Group, *CALOHEE project, Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe*, funded with support from the European Commission, see <https://www.calohee.eu>
7. Germany: IPE e. V., Ingenieurpädagogische Wissenschaftsgesellschaft, ipw-edu.org, info@ipw-edu.org
8. Centre for Engineering Education (CEE), Universiti Teknologi Malaysia, <http://tree.utm.my>
9. Engineers Without Borders International and EWB Chapters in Australia, Brazil, India, Canada, Netherlands, Philippines, UK, USA

IEA Signatories – to date, in progress:

1. Engineering Council UK
2. Institution of Professional Engineers, Japan
3. Engineers Canada, WFEO member
4. Board of Engineers Malaysia
5. Philippines Technological Council, Provisionals signatory, WFEO Member
6. The Hong Kong Institution of Engineers (The HKIE)
7. Engineers Australia
8. Engineers Canada

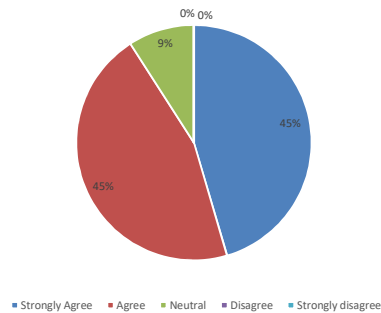
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Feedback Received - Survey

Q1: What was your first reaction to the Proposed Revised Graduate Attributes and Professional Competencies (GAPC) Framework?

Q1: Overall Response to Proposed Changes to GAPC Framework



A total of **90% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" with the proposed changes. 9% were neutral. There were no negative responses.

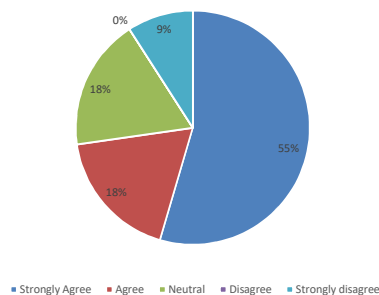
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Feedback Received - Survey

Q2: The Proposed GAPC Framework adequately accounts for changes in engineering practice in the future

Q2: Adequately accounts for changes in engineering practice



A total of **73% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately accounted for future changes in engineering practice. 18% were neutral. 9% were strongly negative.

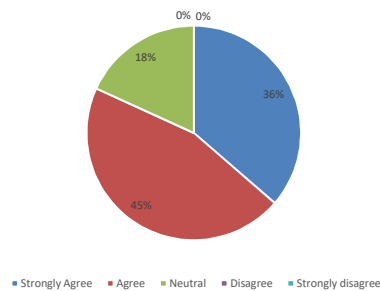
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Feedback Received - Survey

Q3: The Proposed GAPC Framework considers the **impact of new and emerging technologies (AI, ICT, Industry 4.0 etc.) on engineering practice**

Q3: Considers impact of new and emerging technologies



A total of **81% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately accounted for the impact of new and emerging technologies. 18% were neutral. There were no negative responses.

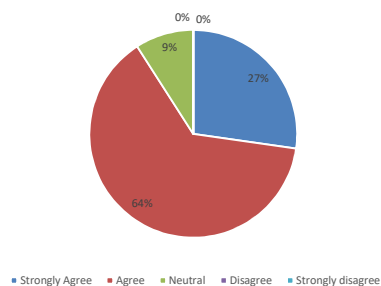
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Feedback Received - Survey

Q4: The Proposed GAPC Framework **accommodates emerging and future engineering disciplines and practice areas**

Q4: Accommodates future and emerging disciplines



A total of **91% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately covered emerging and future engineering disciplines. 9% were neutral. There were no negative responses.

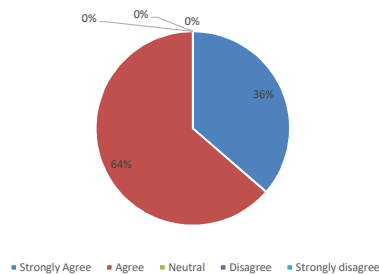
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Feedback Received - Survey

Q5: The Proposed GAPC Framework accounts for the objectives of the UN Sustainable Development Goals

Q5: Incorporates objectives of UN Sustainable Development Goals



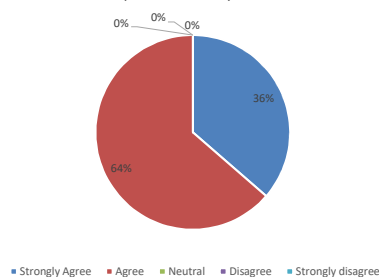
100% of respondents were positive about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately addressed the objectives of the UN Sustainable Development Goals. There were no negative responses



Feedback Received - Survey

Q6: The Proposed GAPC Framework addresses Diversity and Inclusion (Diversity includes visible differences such as gender, race and ethnicity and visible disabilities and non-visible differences such as sexual orientation, social class, heritage, religion, unseen disabilities, and age.)

Q6: Incorporates Diversity and Inclusion



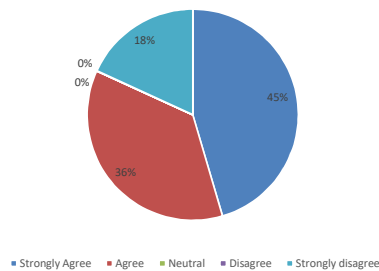
100% of respondents were positive about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately addressed diversity and inclusion in engineering. There were no negative responses



Feedback Received - Survey

Q7: The Proposed GAPC Framework ensures that the future engineer's decision will use critical thinking and more acuity, creativity and innovation

Q7: Includes need for Critical Thinking Skills



A total of **81% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes adequately covered the need for critical thinking skills. **18% were strongly negative.**

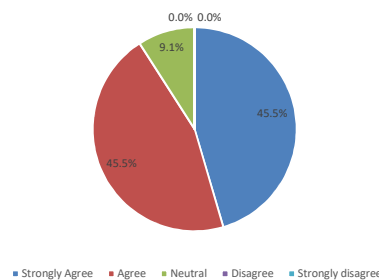
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Feedback Received - Survey

Q8: The Proposed GAPC Framework ensures that the practicing engineer will continue professional development and lifelong learning to be meet evolving industry needs, new technologies and community needs.

Q8: Includes need for Professional Development and Lifelong Learning



A total of **91% of respondents were positive** about the proposed changes and either "Strongly Agreed" or "Agreed" that the changes supported continuous professional development and lifelong learning. disciplines. 9% were neutral. There were no negative responses.

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Further information

- The entire table “A Proposal to Update the GAPC Tables.docx” is available at the WFEO Website: <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.
- The information web page is also mirrored on the IEA website: <https://www.ieagrements.org/about-us/iea-unesco-and-wfeo-collaboration/>

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- Participation
- Influence
- Representation



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



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

www.wfeo.org
@wfeo

info@wfeo.org