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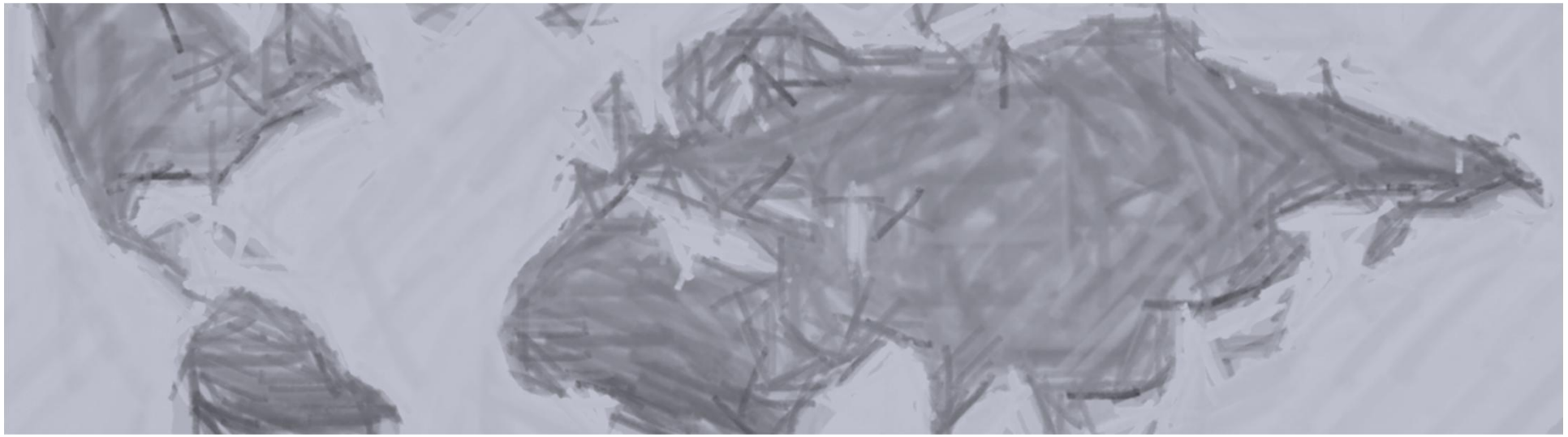
Review of International Engineering Benchmarks for Graduate Attributes and Professional Competencies for Engineers of the Future to successfully advance the UN Sustainable Development Goals

Dr. Marlene Kanga AM
WFEO President 2017-19

7 April 2021



The World Federation of Engineering Organizations:

- The peak international body for professional engineering institutions
- 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
- Co-Chair - Major Science and Technology Group at UN
- Representation at major UN Organisations

- A key objective of the World Federation of Engineering Organizations, since 2018, is to advance the UN SDGs through engineering.
- WFEO is working with UNESCO and other international engineering organizations to advance the 2030 Agenda including the declaration of World Engineering Day for Sustainable Development in November 2019.
- The UNESCO Engineering Report – Engineering for the Sustainable Development Goals, aligns with this vision and shows the important work that needs to be done by engineers and "how engineering can make it happen".
- In addition the report shows that we need to build capacity for more engineers, especially women, with the right skills to advance sustainable development.

UNESCO Engineering Report – Engineering for Sustainable Development, 4 March 2021

EN http://on.unesco.org/Eng2021 , FR: http://on.unesco.org/Ing2021

ES http://on.unesco.org/Ingen21

The second UNESCO Engineering Report – "Engineering for the SDGs", Chapter 1, author Dr Marlene Kanga 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."*

***Engineering* for Sustainable Development**

Message from UN Secretary General Antonio Gutteres to the WFEO Global Engineering Congress, 22-26 October 2018

"The United Nations will continue to count on your engagement and support as we strive to achieve the 17 Sustainable Development Goals – the world's blueprint for building a future of peace and prosperity for all on a healthy planet. ***Every one of the Goals requires solutions rooted in science, technology and engineering****."*

The UN Secretary General agrees, Twitter, 4 March 2021, World Engineering Day,

"As a trained engineer I am passionate about the potential of engineering to help solve the most pressing challenges facing our world"

WFEO – UNESCO
Declaration, signed on March 7, 2018

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

United Nations
Educational, Scientific and
Cultural Organization

WFEO / FMOI

Paris Declaration

Advancing the United Nations Sustainable Development Goals through Engineering

SUSTAINABLE DEVELOPMENT GOALS

The World Federation of Engineering Organizations (WFEO) is the main body for engineering globally, representing nearly 100 nations and some 30 million engineers.

The members of WFEO are the national and regional professional engineering institutions of the world. WFEO is a member of the United Nations Scientific and Technological Community (UN STC) Major Group and has an official Associate status with UNESCO.

UNESCO, as the United Nations agency for education, science and culture, supports engineering through its Natural Sciences Sector, and acknowledges engineering as a powerful means to achieve sustainable development, capacity-building in engineering education and gender equality in developing countries, as well as the safeguarding of world heritage.

CELEBRATING 50 YEARS OF INTERNATIONAL ENGINEERING LEADERSHIP

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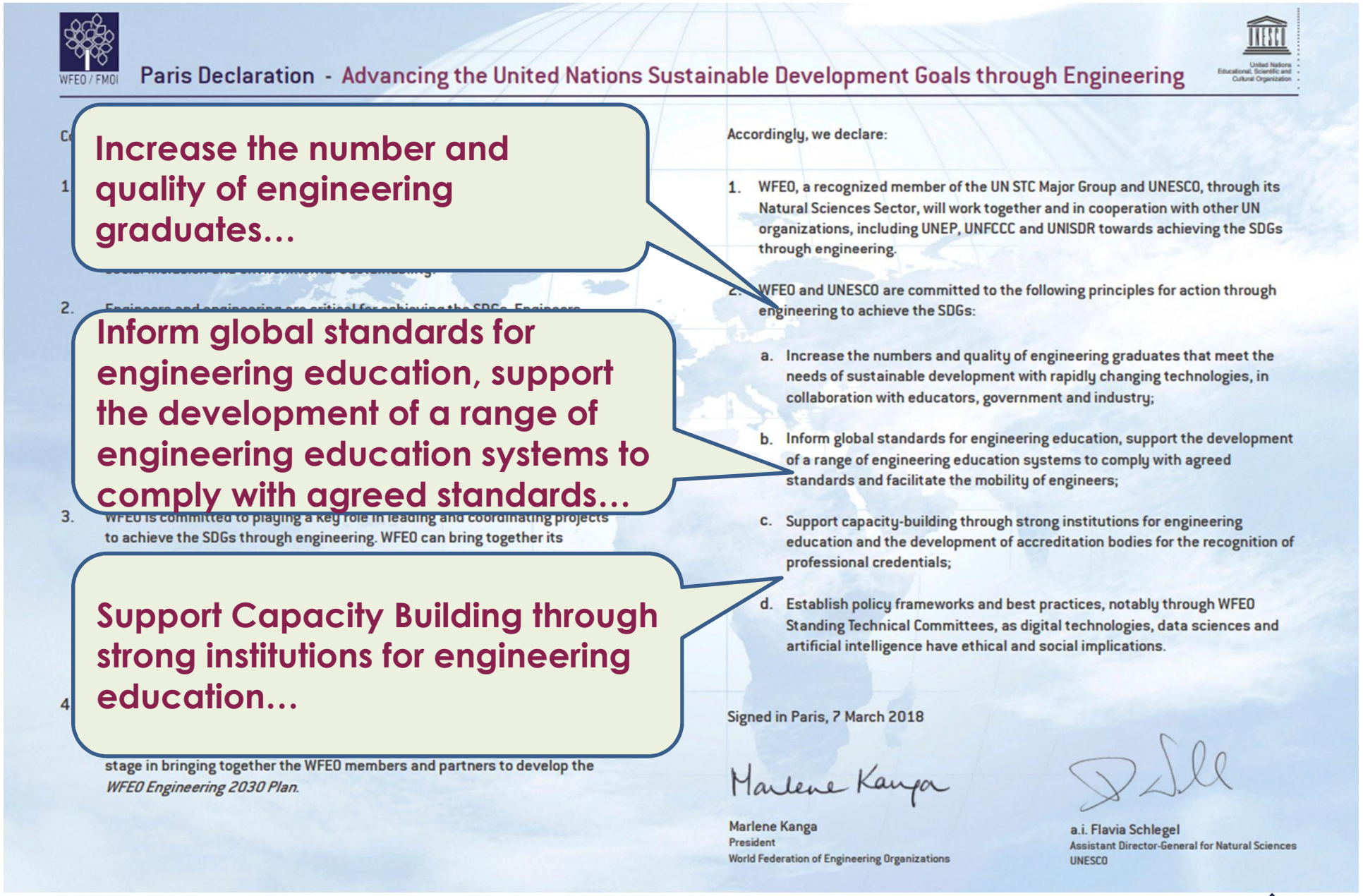


Engineering 2030 – Principles for Action

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

WORKING GROUP 1 - COMPLETE JUNE 2021

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

WORKING GROUP 2

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

These projects:

1. Engineering education for the right skills - Goal 4
2. Develop institutional capacity – Goal 16 accreditation bodies and professional engineering institutions
3. Working in partnership – Goal 17

   UNESCO, WFEO members, International Engineering Alliance and signatories, international engineering organizations

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

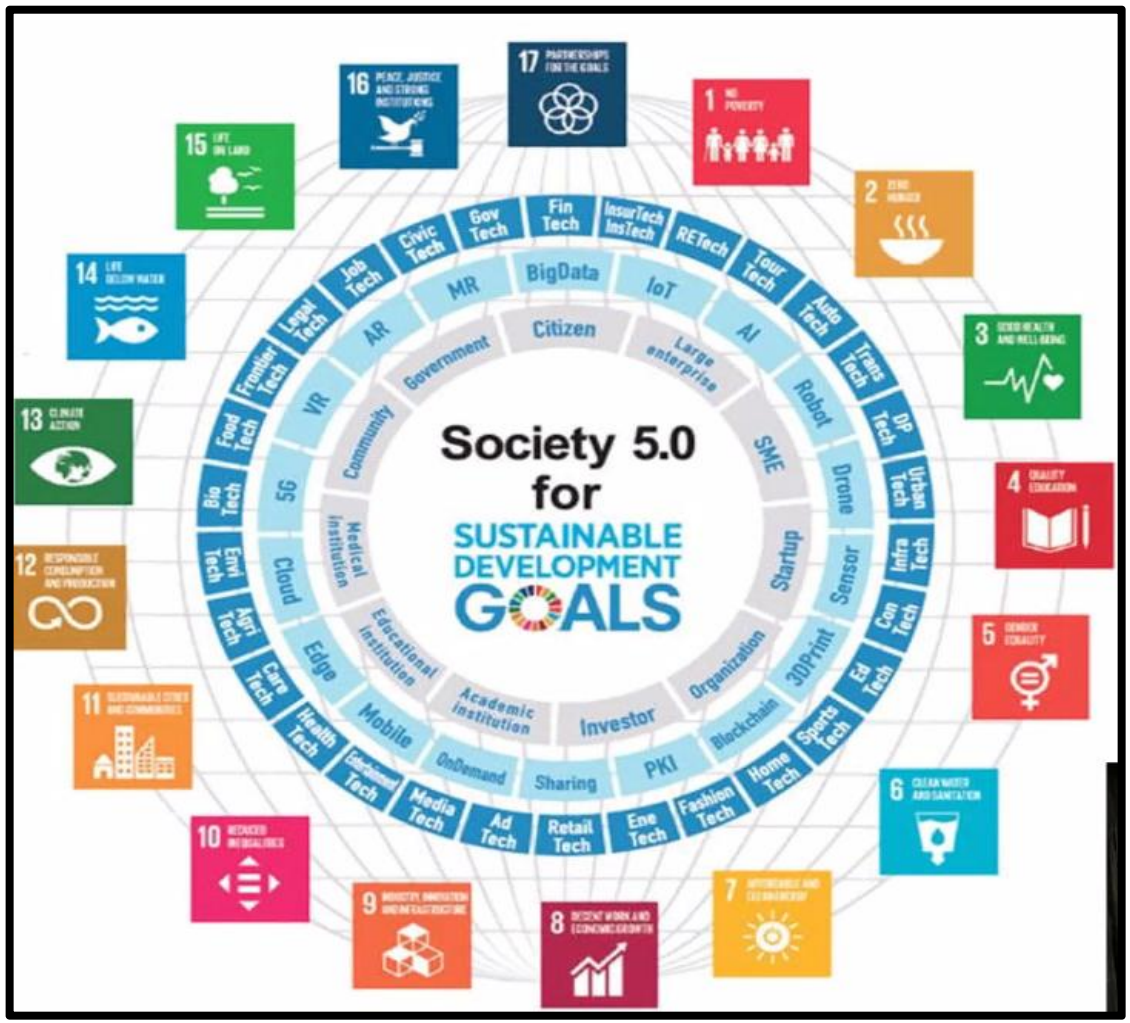
Dr Peggy Oti-Boateng, Director, Capacity Building Section, Natural Sciences Sector UNESCO, speaks at Plenary, WEC2019, Melbourne

Signing of MoU between IEA and WFEO, WEC2019, Melbourne

Recognition of the need for change

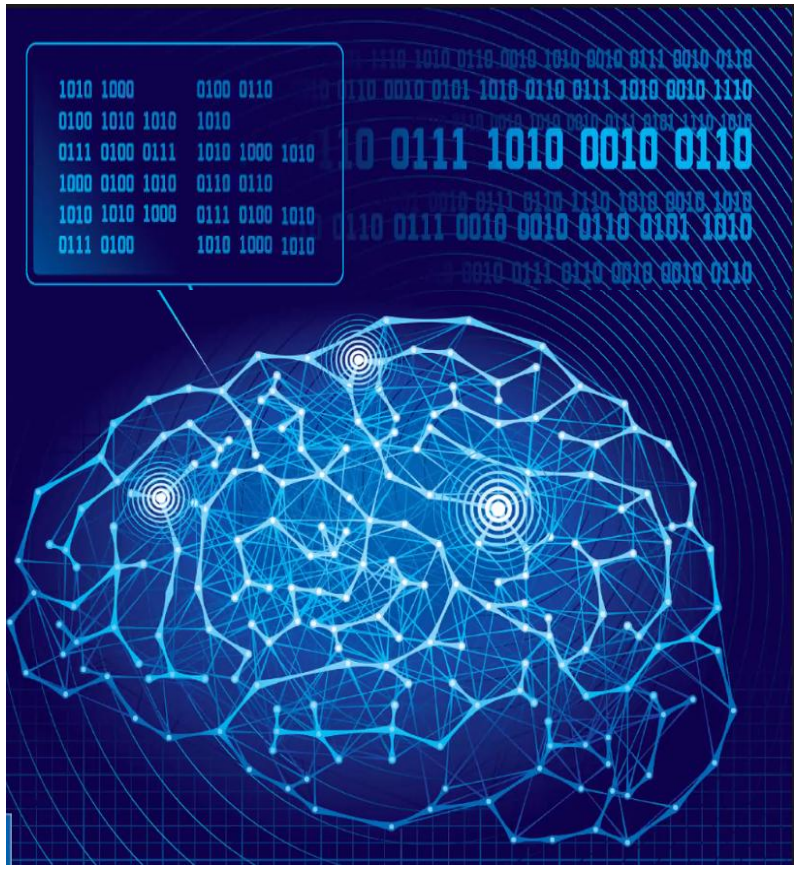
- A great deal of progress has been made by UNESCO WFEO IEA Working Group
- These change include attention to the use of information technologies, data and analytics
- The ability to learn and adapt to new and emerging technologies
- Greater responsibility to society and the environment
- incorporating 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.

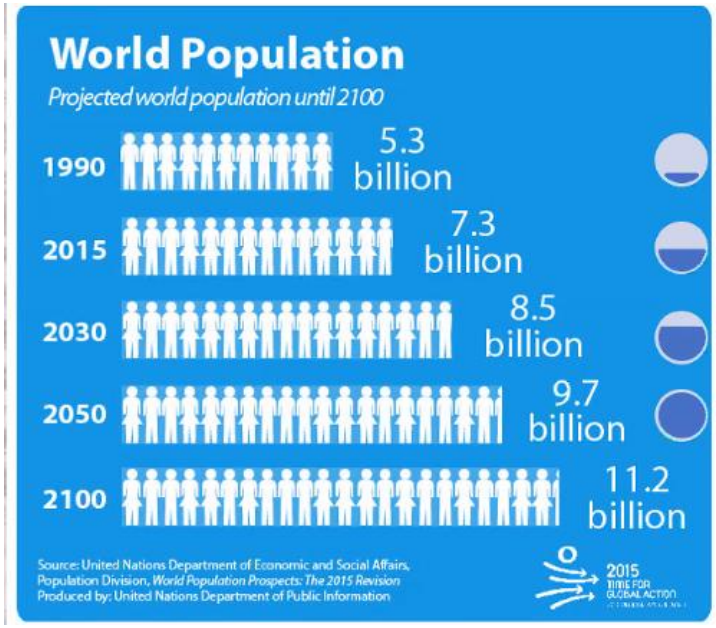
Emerging engineering disciplines and technologies and the UN Sustainable Development Goals



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

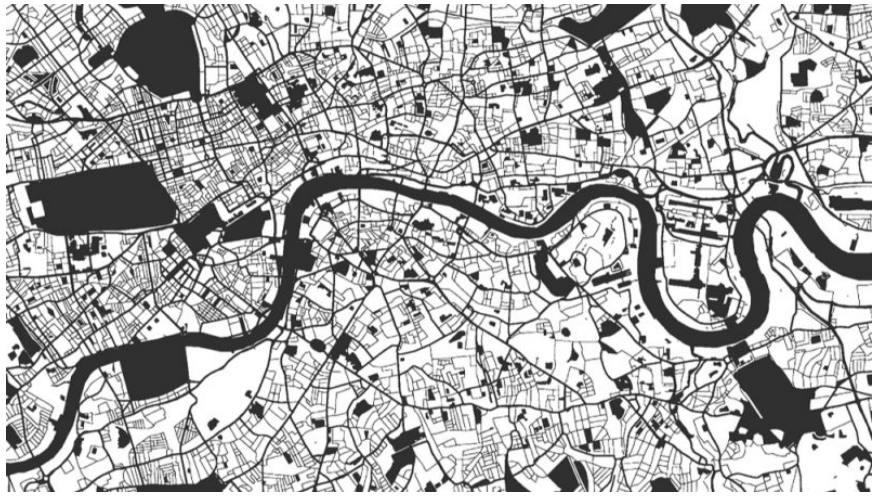
Source: I. Opperman, Enabling our digital future, Feb. 2021

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 civil engineering and 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

***Engineering* for Sustainable Development**

Key areas for change in international engineering education benchmarks

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

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….**

Key areas for change

1. **Accommodate future needs** of engineering professionals and the profession – strengthen the required attributes on team work, communication, ethics, sustainability.
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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.

Consultation to March 2021 on Graduate Attributes and Professional Competencies (GAPC) Framework

- **4 webinars:**
- **Professional Engineering Institutions,**
- **Engineering Educators and Universities**
- **Women,**
- **Industry**
- **932 attending, 60 countries**

- **Survey – responses from every continent**

- **15 Detailed submissions, every continent**

Continent	No.	%
Africa	75	8%
Asia	665	71%
Americas	96	10%
Europe	54	6%
Middle East	29	3%
Oceania	13	1%
Total	932	100%

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

Feedback to March 2021 has been overwhelmingly positive and constructive

1. George Mason University, VA USA
2. University of Western Australia
3. American Society of Civil Engineers, ASCE Body of Knowledge Version 3 (BOK3)
4. South African Institution of Civil Engineers (SAICE)
5. International Network for Women Engineers and Scientists (INWES)
6. University of Bath, UK
7. 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
8. Germany: IPE e. V., Ingenieurpädagogische Wissenschaftsgesellschaft, ipw-edu.org, info@ipw-edu.org
9. Centre for Engineering Education (CEE), Universiti Teknologi Malaysia, http://tree.utm.my
10. Engineers Without Borders International and EWB Chapters in Australia, Brazil, India, Canada, Netherlands, Philippines, UK, USA

Feedback to March 2021 has been overwhelmingly positive and constructive

IEA Signatories

1. **Engineering Council UK**
2. **Institution of Professional Engineers, Japan**
3. **Engineers Canada, WFEO member**
4. **Board of Engineers Malaysia**
5. **Philippines Technological Council, Provisional IEA signatory, WFEO Member**
6. **The Hong Kong Institution of Engineers (The HKIE), WFEO Member**
7. **Engineers Australia, WFEO Member**
8. **Engineers Canada, WFEO Member**
9. **ABET (Accreditation Board for Engineering and Technology), USA**
10. **Board of Professional Engineers of Bangladesh (BPERB), Institute of Engineers Bangladesh (IEB), Provisional IEA signatory, WFEO Member**
11. **Engineering New Zealand, WFEO Member**
12. **Erbil Payzın (founding member MUDEK Turkey)**
13. **Myanmar Engineering Council, Myanmar, Provisional IEA signatory, WFEO Member**

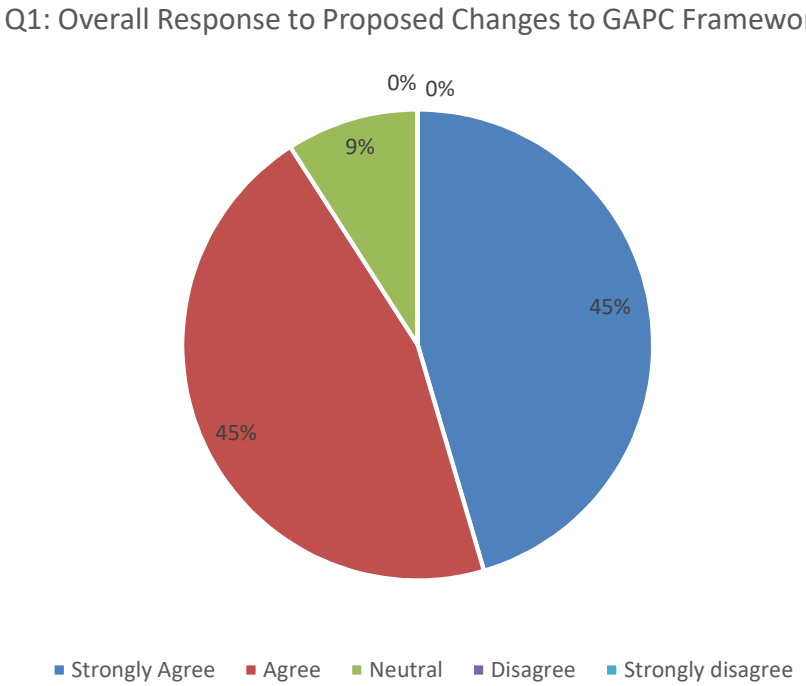
Feedback to March 2021 has been overwhelmingly positive

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

Professor Tim Ibell FREng
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

Feedback Received - Survey

Q1: What was your first reaction to the Proposed Revised Graduate Attributes and Professional Competencies (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.

Full details of survey and responses at: **WFEO: https://bit.ly/3fg8Fdh**

Addressing Feedback and remaining work

1. All feedback has been reviewed thoroughly by the working group with clear reasons for acceptance or not
2. At all times, the WG noted that the GAPC will be used in the field by many educational accreditation and professional registering organizations. Thus the WG questioned, at every step, the reason for each change, how the changes can be implemented in an engineering curriculum, how a program can demonstrate attainment, and how an engineer can list the attributes in a CV.
3. The proposed GAPC recognises and addresses the changes that are needed to address technology, learning and practice modes in engineering. However the GAPC does not prescribe how attainment is demonstrated. This is the work of the accreditation bodies in each jurisdiction. Guidelines may be developed in future, but essentially, these bodies should develop these for their jurisdiction, reflecting local culture, practices and systems. This will ensure that the GAPC is relevant in every context around the world.

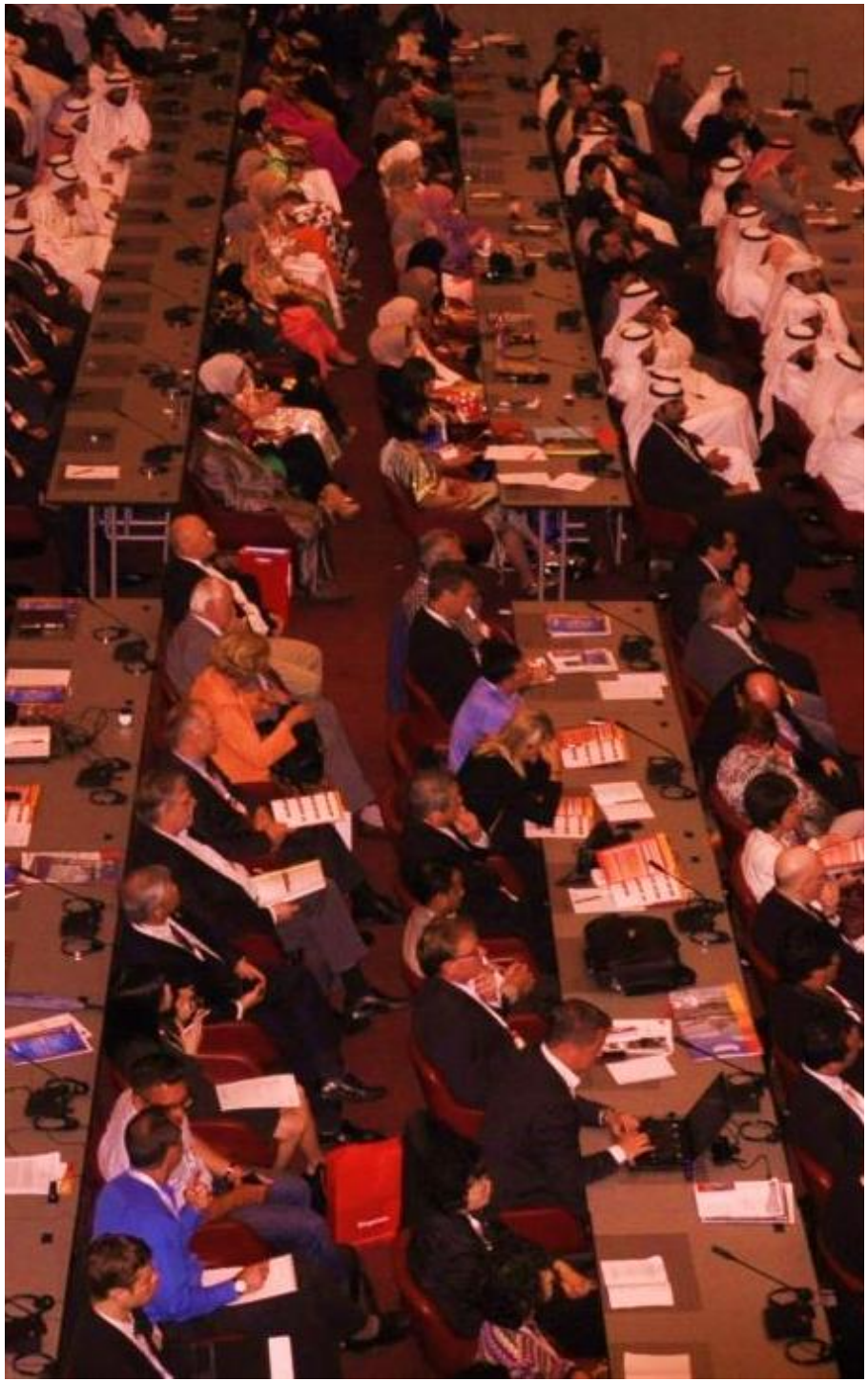
More information on the review of the Graduate Attribute and Professional Competency (GAPC) Framework

- **The entire table "A Proposal to Update the GAPC Tables.docx" is available at :**

- **WFEO: https://bit.ly/3fg8Fdh**

- **IEA: https://www.ieagreements.org/about-us/iea-unesco-and-wfeo-collaboration**

- **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.**



Engineering for Sustainable Development

- Participation
- Influence
- Representation

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

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

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