Raising Engineering Education Standards through Accreditation and International Benchmarking

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Chair, Engineers Australia Accreditation Board (2007-12)
Chair, Sydney Accord (2011-15)
Context - Overview

- National program accreditation by Engineers Australia since 1980s - has strong support from faculties for driving of education improvement (with ACED and AAEE)

- EA standards and expectations on learning outcomes and good education practices align with AQF, TEQSA and Higher Education Standards

- Internationally:
  - the Washington Accord (Int’l Eng. Alliance – IEA) has validated and raised global standards since 1989
  - the IEA and the European accreditation network (ENAAE-EurACE) is working towards common best-practices
  - Australian participation in the OECD Assessment of Higher Education Learning Outcomes (AHELO) feasibility study during 2009-13 has framed work on outcomes assessment
assessment of graduate outcomes is central

government education – funding & regulation
(HEd standards, qualifications framework, etc.)

higher education institution (HEI) – educational awards & research
(operational policies and QA)

degree programs

student assessment

external outcomes assessment
(e.g. AHELO for HEI improvement)

employers observe graduates’ capabilities over HEIs

formalised by external professional bodies with program accreditation to national learning-outcome standards, referenced to international practice (e.g. Washington Accord)
external accreditation actively supports Higher Education standards compliance

four clauses from the HEd Standards Framework (2015)

3.1.2 The **content and learning activities** of each course of study engage with advanced knowledge and inquiry consistent with the **level of study** and the **expected learning outcomes**.

3.1.5 Where **professional accreditation** of a course of study is required for graduates to be eligible to practise, the course of study is accredited and continues to be accredited by the relevant professional body.

5.3.4 Review and improvement activities include regular **external referencing** of the success of student cohorts against comparable courses of study, including: ... progression rates ... **assessment of learning outcomes** ...of selected units of study.

5.3.7 The results of regular interim monitoring, comprehensive reviews, **external referencing** and student feedback are used to mitigate future risks to the quality of the education provided and to **guide and evaluate improvements** ...
Engineering is about creating new and complex infrastructure, products, systems and services

- multi-dimensional **performance specifications** and increasingly tough societal demands that necessitate **innovation**
- through **design** and **implementation** by multi-disciplinary and multi-level **collaborative teams** (of specialists)
- often **global** - multinational companies, supply chains, technical standards and globally mobile engineers
- sustained over **long periods** and with **enduring impacts**
EA program accreditation has to be forward-looking and is outcomes-based

- 1980 to mid-1990s, mainly input-oriented after 4-year degree requirement introduced for professional engineer degrees
- 10 broad outcomes introduced during 1996-2000
- from 1994, parallel development of 16 “Stage 1 Competencies” (in Knowledge, Applications, Personal areas) formally adopted as program outcomes from 2004
- answers accreditation questions:
  - Do the educational environment, program design and implementation, and quality systems assure delivery of the Stage 1 competencies (at threshold level) to all graduates for the next five years?
  - Is the range and depth of technical competence appropriate to the discipline specialisation?
- by holistic peer judgement against the accreditation criteria
- to determine accreditation status, conditions (reporting requirements) and recommendations for improvement
Engineers Australia accreditation - coverage and value

- Engineers Australia accreditation processes cover “entry to practice” qualifications (~ 11,000 graduates); engineering practice is **not regulated** at entry qualification stage.

<table>
<thead>
<tr>
<th>occupation</th>
<th>post-school educ yrs and award</th>
<th>AQF level</th>
<th># of prov’s /prog’s</th>
<th>internat’l Accord</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional Engineer</td>
<td>5 yr MEng, 4 yr BEng (Hons)</td>
<td>9, 8</td>
<td>12 / 76, 38 / 331</td>
<td>Washington</td>
</tr>
<tr>
<td>Engineering Technologist</td>
<td>3 yr BEngTech</td>
<td>7</td>
<td>16 / 35</td>
<td>Sydney</td>
</tr>
<tr>
<td>Engineering Associate</td>
<td>2 yr Adv. Dip., 2 yr Assoc. Deg.</td>
<td>6</td>
<td>5 / 11, 5 / 17</td>
<td>Dublin</td>
</tr>
</tbody>
</table>

- Participation in EA accreditation is voluntary – but sought by all providers of professional engineering programs.

- EA accreditation is **valued** by prospective students (esp. int’ls), graduates, employers, providers and the profession.
the Accreditation Criteria

academic program – “fit for purpose”
• award title
• outcomes specification (narrative and PLOs)
• structure & pedagogy
• curriculum (unit) content and assessment (ULOs)
• exposure to engineering practice

operating environment:
• organisational structure
• staff profile
• leadership and culture
• facilities
• funding
• student profile

quality systems for:
• stakeholder engagement
• student feedback
• student assessment
• outcomes review
• educational design
• review and amendment
• benchmarking
<table>
<thead>
<tr>
<th>Units of Competency</th>
<th>Elements of Competency (Professional Engineer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Knowledge &amp; Skill Base</td>
<td>1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and engineering fundamentals applicable to the engineering discipline.</td>
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<td></td>
<td>1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.</td>
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<td>1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline.</td>
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<td></td>
<td>1.4 Discernment of knowledge development and research directions within the engineering discipline.</td>
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<td></td>
<td>1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline.</td>
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<tr>
<td></td>
<td>1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific engineering discipline.</td>
</tr>
<tr>
<td>Units of Competency</td>
<td>Elements of Competency (Professional Engineer)</td>
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<tr>
<td>---------------------------------------</td>
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</tr>
<tr>
<td>2 Engineering Application Ability</td>
<td>2.1 Application of established engineering methods to complex engineering problem solving.</td>
</tr>
<tr>
<td></td>
<td>2.2 Fluent application of engineering techniques, tools and resources.</td>
</tr>
<tr>
<td></td>
<td>2.3 Application of systematic engineering synthesis and design processes.</td>
</tr>
<tr>
<td></td>
<td>2.4 Application of systematic approaches to the conduct and management of engineering projects.</td>
</tr>
<tr>
<td>3 Professional and Personal Attributes</td>
<td>3.1 Ethical conduct and professional accountability</td>
</tr>
<tr>
<td></td>
<td>3.2 Effective oral and written communication in professional and lay domains.</td>
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<td></td>
<td>3.3 Creative, innovative and pro-active demeanour.</td>
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<td></td>
<td>3.4 Professional use and management of information.</td>
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<td></td>
<td>3.5 Orderly management of self and professional conduct.</td>
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<tr>
<td></td>
<td>3.6 Effective team membership and team leadership.</td>
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</tbody>
</table>
Each competency has a set of indicators of graduate attainment (action oriented evidence) ...

<table>
<thead>
<tr>
<th>2.1 Application of established engineering methods to complex engineering problem solving (complex defined by IEA as multi-facetted and open-ended)</th>
<th>a) Identifies, discerns and characterises salient issues, determines and analyses causes and effects, justifies and applies appropriate simplifying assumptions, predicts performance and behaviour, synthesises solution strategies and develops substantiated conclusions.</th>
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<td></td>
<td>b) Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic.</td>
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<td></td>
<td>c) Competently addresses engineering problems involving uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors.</td>
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<td></td>
<td>d) Investigates complex problems using research-based knowledge and research methods.</td>
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</tbody>
</table>
| 2.1 Application of established engineering methods to complex engineering problem solving. (complex defined by IEA as multi-facetted and open-ended) | e) **Partitions** problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then **re-combines** to form a whole, with the integrity and performance of the overall system as the paramount consideration.  

f) **Conceptualises** alternative engineering approaches and **evaluates** potential outcomes against appropriate criteria to justify an optimal solution choice.  
g) **Critically reviews and applies** relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations.  
h) **Identifies, quantifies, mitigates and manages** technical, health, environmental, safety and other contextual risks associated with engineering application in the designated engineering discipline.  
i) **Interprets and applies** legislative and statutory requirements applicable to the engineering discipline. |
evidence for accreditation

- self-study report against criteria, including
  - mappings of course unit learning outcomes to overall program learning outcomes (targets)
  - consistent unit descriptions (as for students)
- evaluation team (typically 12) - preliminary teleconference
  - Identification of issues and additional information
- 3-day evaluation visit
  - samples of unit material and student assessments, including project work and employment (WIL) reports
  - inspection of a sample of laboratories
  - meetings with students, graduates, employers, teaching and support staff, program, faculty and university leaders
  - debriefing on preliminary findings and decisions
accréditation outcomes – areas for improvement

- over 2008 – 2012 EA considered 637 programs (89 visits)

- recommendations for improvement (over all reports)
  - curriculum design and delivery (1.8 refs per visit report)
  - outcomes specification and mapping (1.1)
  - staffing numbers, development, culture, leadership (0.9)
  - students’ self reflection and development as stakeholders in the education process (0.8)
  - exposure to engineering practice (0.6)
  - industry advisory processes (0.6)
  - assessment, moderation and benchmarking (0.5)
  - quality systems (0.5)
  - facilities and technical support (0.4)
current areas of performance improvement through collaboration

- EA - ACED (faculty leaders) – AAEE (Australasian Association for Engineering Education) project areas currently include:
  - engineering practice and work integrated learning
  - student e-portfolios
  - sharing teaching resources in key areas

- since 2007, the EE community has won > 30 projects from ALTC/OLT and others on education improvement

- this and other work contributes to high international regard for Australian engineering education and educators
  - evidence-based research in engineering education
  - problem-based learning
  - group work and self- and peer assessment
  - advanced visualisation tools

- but reliable outcomes assessment remains a big challenge
the International Engineering Alliance: 
the Washington Accord 1989-2015

- from 6 to 17 Signatories
- 6 provisionals: China, Bangladesh, Pakistan, Philippines, Peru, Mexico
- tough admission, then 6-year peer-reviews of processes and ‘compliance’ with graduate attribute exemplar
- Signatories ‘recognise’ each others’ programs and graduates as equivalent to their own
- protocols for recognition of out-of-country accreditation
- IEA has an annual forum and decision meetings of 3 Accords and 4 Agreements
- co-operation agreement with parallel European body

Successful voluntary collaborative innovation for international standards setting, benchmarking and quality improvement

Underpins global engineer mobility
attribute details are different for the three Accords
- GA v3 (2013) includes stronger statements on sustainability
- signatories have to demonstrate compliance as ‘substantial equivalence’ by peer-review: gap analysis and observation
the European Higher Education Area (EHEA) has a two cycle award framework to increase student mobility, etc.

compatibility with the IEA Accords is complex but necessary (with 4 common members of Washington Accord and the European Network for the Accreditation of Engineering Education - ENAEE)

complexity comes from IEA members being profession-led, while ENAEE members focus on national compliance with EHEA system (qualifications) and directives

the Accord leaders and ENAEE have a cooperation agreement to enhance mutual working between the two systems

observe each others’ annual discussion forums, and in 2015 jointly published: *Best Practice in Accreditation of Engineering Programmes: An Exemplar*

ongoing discussions on describing and assessing threshold graduate attributes for each educational and occupational level
Can learning outcomes be directly assessed? The OECD AHELO feasibility study

- Employers, governments, students, parents, universities seek evidence of claims of graduates’ learning outcomes, against standards, and/or comparisons with peers and competitors

  (Comparison ranking is not the role of program accreditation)

- Many professions use registration examinations (including several Washington Accord signatories), so not directly focussed on students’ learning in their degree

- Examples of direct assessment of graduating students include
  - Australasian Medical Assessment Collaboration (120 test items)
  - The 2008-13 OECD AHELO feasibility study – in generic skills, civil engineering, economics

- ACER won the contract to managed the AHELO project

- 9 Australian engineering faculties participated in the trial
  - 90 minute web-based test instrument of (MCQs) on “fundamental knowledge” and “engineering thinking” (Constructed Responses)
OECD - AHELO civil engineering strand - summary

- test taken in 9 countries and 92 institutions (Feb- July 2012)
  - results were a strong stimulus to some
  - also revealed participation and contextual difficulties

- findings demonstrated (to OECD satisfaction)
  - translatability, operability and validity (discrimination power)
  - potential for educational improvement by university (and country)

- but OECD is not following up as originally planned

- the trial also suggests value of internationalised test instruments to strengthen accreditation benchmarking
  - Japan, Canada, USA and Australia are collaborating in devising outcomes assessments in mechanical engineering
Conclusions

- local and international professional accreditation of engineering programs continue to raise educational standards
- participation in the Washington Accord has strongly supported Australian international education
- the ‘Accord’ model of ‘exemplars’ and ‘substantial equivalence’ meets global requirements and accommodates local variations of educational systems and engineering practice
- collaboration between accrediting bodies, Deans Councils and academic societies has promoted and delivered education standards improvement
- as in all engineering projects, we will continue to work on improvements – as resources permit
Postscript and References

Standardisation of Terms and Statistics

- Could we standardise the name for award “program” or “course”?
- Could we standardise the number of program units (credit points) per academic year?
- Could we adopt an Australian standard base for GPA?
- Is it time to revise the national Higher Education statistics to provide more useful information that the community needs - contemporary education areas, occupation titles and the AQF?

Websites for further information

International Engineering Alliance website: www.ieagreements.org

Engineers Australia Accreditation website:

AHELO Project Website: www.oecd.org/education/skills-beyond-school/testingstudentanduniversityperformancegloballyoeecdsahelo.htm