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Quality Assurance of Global Engineering Education through Benchmarking of Accreditation Systems

International Engineering Education Reform and Development
17~19 November 2014, Hangzhou, China

A Keynote Address
by

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Synopsis

- Outcomes-based accreditation framework for quality assurance of global engineering education.
- International accords or agreements, such as the Washington Accord, facilitates multi-lateral recognition of substantial equivalency of programmes.
- Accredited degrees are the foundation of recognized qualifications of international mobility agreements for engineers.
- Outcomes-based assessment and evaluation systems must be put in place at the universities to verify the achievement of defined programme education objectives and graduate attributes.
- Accreditation requirements based on the Washington Accord framework.


Engineers in Society


Dam failure - Wikipedia

Impact to Public

Brazil stadium collapse - Times of AP

- Safeguarding life, public welfare, safety, health, and property

2012 collapsed residential building in Ningbo - Xinhua

2013 India building collapse – theGuardian

Competencies and experience for practice of professional engineering

- Define, investigate, and analyse complex problems
- Design or develop solutions to complex problems
- Evaluate the outcomes and impacts of complex activities
- Be responsible for making decisions
- Manage engineering activities
- Exercise sound professional engineering judgment
- Communicate clearly

Competency Requirements

- Competency requirements of Professional Engineer, Engineering Technologist and Engineering Technician
- Engineer – solution of complex engineering problem
- Engineering Technologist – broadly defined and applied engineering procedures, processes, systems or methodologies
- Engineering Technician – well-defined engineering problems

International mobility and benchmarking of professional engineers

- Engineers are more mobile as a result of global economy
- Cross-border professional engineering services are jealously guarded
- Accredited engineering degrees fundamental requirement

Overview of Accreditation Organisations

Nature of Accrediting Body

- Statutory / Government body, e.g. a division of ministry of education
- Engineers Registration Board, e.g. PEC, BEM
- Professional/Learned Engineering Institution, e.g. Institution of Engineers, Singapore, Hong Kong Institution of Engineers
- Independent Accreditation Board, e.g. ABET, ABEEK

Organization and composition of Accreditation Board/Committee

- Embedded within registration board/professional institution?
- Independent accreditation body?

Key Attributes of a good accreditation board

- Independent
- Key stakeholders representation
- Good governance
- Transparent
- Clear policy and requirements
- Accreditation criteria
- Accreditation procedure

Key Attributes of a good accreditation board

- Competent, well-trained program evaluators
- Effective and efficient accreditation visits
- Professional decision making process
- Oversight, appeal
- Benchmark with highest international standards
- Commitment to CQI
- Sustainable

International Scene

International Scene

- Washington Accord
- Sydney Accord
- Dublin Accord
- Seoul Accord
- ENAEE – EUR-ACE Label
- (*NABEEA*) Network of Accreditation Bodies for Engineering Education in Asia

Success of Washington Accord

- Well-established and internationally recognized
- High standard set for Graduate Attributes and Professional Competencies
- Unanimous agreement in admission of new signatories – after provisional membership and rigorous review
- Periodic monitoring/review by fellow signatories
- 4-year engineering programs

ENAEE

- European Network for Engineering Accreditation – founded in 2006
- European body for awarding authorization to accreditation agencies to award the EUR-ACE label
- The EUR-ACE® framework and accreditation system provides a set of standards that identifies high quality engineering degree programmes primarily in Europ
- Accreditation requirements for 1st cycle and 2nd cycle program

Accreditation Criteria

- Typical Criteria include:
  1) Mission & Programme Educational Objectives
  2) Student Learning Outcomes
  3) Curriculum and Teaching Processes
  4) Students
  5) Faculty members
  6) Facilities & learning environment
  7) Institutional support & financial resources
  8) Governance
  9) Interaction between institution & industry
  10) Research & development
  11) Specific Programme criteria

Learning Outcomes

- Knowledge and competencies profiles
- Graduate attributes which form the student learning outcomes:
  1. Engineering knowledge
  2. Problem analysis
  3. Design/development of solutions
  4. Investigation
  5. Modern tool usage
  6. The engineer and society
  7. Environment and sustainability
  8. Ethics
  9. Individual and team work
  10. Communications
  11. Project management and finance
  12. Life-long learning

INTERNATIONAL ENGINEERING ALLIANCE

Constituent Agreements

Washington Accord	International Professional Engineers Agreement
Sydney Accord	International Engineering Technologists Agreement
Dublin Accord	APEC Engineer Agreement

Graduate Attributes and Professional Competencies

Version 3: 21 June 2013

This document is available through the IEA website: http://www.ieagreements.org.

Graduate Attributes

- *Graduate attributes form a set of individually assessable outcomes indicative of the graduate's potential competency.*
- *Attributes expected of graduate from an accredited programme - expected capability appropriate to the type of programme.*
- The graduate attributes are intended to assist outcomes-based accreditation criteria.

Complex problems

(A requirement of WA)

- *Involve wide-ranging or conflicting technical, engineering and other issues*
- *Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models*
- *Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach*
- *Involve infrequently encountered issues*
- *Are outside problems encompassed by standards and codes of practice for professional engineering*
- *Involve diverse groups of stakeholders with widely varying needs*
- *Have significant consequences in a range of contexts*
- *Are high level problems including many component parts or sub-problems*

4.2 Range of Engineering Activities

Attribute	Complex Activities
Preamble	**Complex activities** means (*engineering*) activities or projects that have some or all of the following characteristics:
Range of resources	**EA1:** Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)
Level of interactions	**EA2:** Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues,
Innovation	**EA3:** Involve creative use of engineering principles and research-based knowledge in novel ways.
Consequences to society and the environment	**EA4:** Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
Familiarity	**EA5:** Can extend beyond previous experiences by applying principles-based approaches

5.1 Knowledge profile

A Washington Accord prpgramme provides:	**A Sydney Accord programme** provides:
WK1: A systematic, theory-based understanding of the **natural sciences** applicable to the discipline	**SK1**: A systematic, theory-based understanding of the **natural sciences** applicable to the sub-discipline
WK2: Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline	**SK2**: Conceptually-based **mathematics**, numerical analysis, statistics and aspects of computer and information science to support analysis and use of models applicable to the sub-discipline
WK3: A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline	**SK3**: A systematic , theory-based formulation of **engineering fundamentals** required in an accepted sub-discipline
WK4: Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	**SK4**: Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for an accepted sub-discipline
WK5: Knowledge that supports **engineering design** in a practice area	**SK5**: Knowledge that supports **engineering design** using the technologies of a practice area
WK6: Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline	**SK6**: Knowledge of **engineering technologies** applicable in the sub-discipline
WK7: **Comprehension of** the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability	**SK7**: **Comprehension of** the role of technology in society and identified issues in applying engineering technology: ethics and impacts: economic, social, environmental and sustainability
WK8: Engagement with selected knowledge in the **research literature** of the discipline	**SK8**: Engagement with the **technological literature** of the discipline
A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 4 to 5 years of study, depending on the level of students at entry.	A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 3 to 4 years of study, depending on the level of students at entry.

5.2 Graduate Attribute Profiles

References to the Knowledge Profile are shown thus: (WK1 to WK4)

Differentiating Characteristic	... for Washington Accord Graduate	... for Sydney Accord Graduate
Engineering Knowledge:	**WA1**: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems.	**SA1**: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in SK1 to SK4 respectively to defined and applied engineering procedures, processes, systems or methodologies.
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. (WK1 to WK4)	**SA2**: Identify, formulate, research literature and analyse *broadly-defined* engineering problems reaching substantiated conclusions using analytical tools appropriate to the discipline or area of specialisation. (SK1 to SK4)
Design/ development of solutions: Breadth and uniqueness of engineering problems i.e. the extent to which problems are original and to which solutions have previously been identified or codified	**WA3**: Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (WK5)	**SA3**: Design solutions for *broadly- defined* engineering technology problems and *contribute to* the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (SK5)
Investigation: Breadth and depth of investigation and experimentation	**WA4**: Conduct investigations of *complex* problems 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.	**SA4**: Conduct investigations of *broadly-defined* problems; locate, search and select relevant data from codes, data bases and literature (SK8), design and conduct experiments to provide valid conclusions.
Modern Tool Usage: Level of understanding of the appropriateness of the tool	**WA5**: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *complex* engineering problems, with an understanding of the limitations. (WK6)	**SA5**: Select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *broadly-defined* engineering problems, with an understanding of the limitations. (SK6)

The Engineer and Society: Level of knowledge and responsibility	**WA6**: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems. (WK7)	**SA6**: Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering technology practice and solutions to broadly defined engineering problems. (SK7)
Environment and Sustainability: Type of solutions	**WA7**: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (WK7)	**SA7**: Understand and evaluate the sustainability and impact of engineering technology work in the solution of broadly defined engineering problems in societal and environmental contexts. (SK7)
Ethics: Understanding and level of practice	**WA8**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (WK7)	**SA8**: Understand and commit to professional ethics and responsibilities and norms of engineering technology practice. (SK7)
Individual and Team work: Role in and diversity of team	**WA9**: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	**SA9**: Function effectively as an individual, and as a member or leader in diverse teams.
Communication: Level of communication according to type of activities performed	**WA10**: Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	**SA10**: Communicate effectively on *broadly-defined* engineering activities with the engineering community and with society at large, by being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
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.	**SA11**: Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member or leader in a team and to manage projects in multidisciplinary environments.
Lifelong learning: Preparation for and depth of continuing learning.	**WA12**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	**SA12**: Recognize the need for, and have the ability to engage in independent and life-long learning in specialist technologies.

Challenges

- Requirements for professional engineering practices set stringent requirements on program outcomes, e.g. project management & finance, ethics, environment & sustainability, ……
- Requirements of core subjects in traditional engineering disciplines

Challenges

- In developed countries, less than 5% of engineering graduates are practicing as traditional professional engineers.
- Broad-based engineering education opens up opportunities for diverse careers for the engineers.
- Top universities are now offering innovative curriculum and pedagogy for nurturing technically-grounded leaders and innovators. The education is multidisciplinary, with a good grounding in science, technology, arts, humanities and social sciences.
- Such innovative curriculum and pedagogy may face problems when subject to strict accreditation requirements of traditional engineering disciplines which demand comprehensive and in-depth coverage of core subjects.

Challenges

- Accreditation requirements should not stifle innovative curriculum and pedagogy whilst upholding the high standard and core competency for the practice of professional engineering, both locally and internationally.

Quality Assurance

Quality assurance

- Accreditation is not a ranking system.
- It is an assurance that a program or institution meets established quality standards.
- The role of accreditation is to provide periodic external review in support of the program's continuous improvement process.

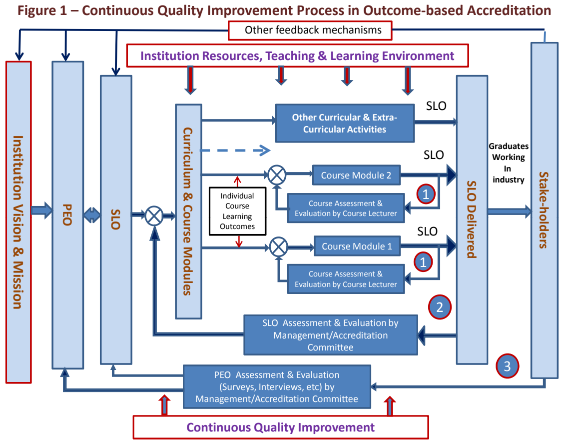
TRADITIONAL APPROACH FOR QUALITY ASSURANCE OF ENGINEERING PROGRAMMES

- Focused on the input & process quality
- The criteria for accreditation may typically include the following list:
  - Organization and governance
  - Financial resources
  - Physical resources and facilities
  - Faculty and staff
  - Student intake quality
  - Teaching – learning process
  - Co-curricular and extra-curricular activities
  - Student services & counseling
  - Research & Development
  - Industrial interaction

OUTCOMES-BASED APPROACH FOR ENGINEERING PROGRAMME ACCREDITATION

- Knowledge and competencies profiles
- Graduate attributes which form the student learning outcomes:
  - Engineering knowledge
  - Problem analysis
  - Design/development of solutions
  - Investigation
  - Modern tool usage
  - The engineer and society
  - Environment and sustainability
  - Ethics
  - Individual and team work
  - Communications
  - Project management and finance
  - Life-long learning

Figure 1 – Continuous Quality Improvement Process in Outcome-based Accreditation



CONTINUOUS QUALITY IMPROVEMENT PROCESS WITHIN OUTCOMES-BASED ACCREDITATION

- Loop (1) - involvement of the course teacher in the continuous quality improvement process – fast response
- Loop (2) - achievement of SLO at the programme level is evaluated at the exit point
- Loop (3) - achievement of the programme education objectives from inputs and feedbacks from the stakeholders, e.g. industry employers and alumni

CHALLENGES IN OBA IMPLEMENTATION

- Challenges to the accreditation boards include:
  - Setting high standards to differentiate graduate attributes (learning outcomes) between engineering degree programmes and engineering technology programmes
  - Aligning required knowledge profile and graduate attributes to international benchmarks, such as those of WA
  - Communicating clearly to education providers of the standards and requirements of OBA

CHALLENGES IN OBA IMPLEMENTATION

- Challenges to the accreditation boards include:
  - Training programme evaluators to be well-verse with standards, procedure and requirements of OBA
  - Instituting a system of continuous quality improvement mechanism within the accreditation board
  - Compromising on standards when subject to external pressure

CHALLENGES IN OBA IMPLEMENTATION

- **Challenges to the education providers include:**
  - Understanding clearly the requirements, procedure and policy of OBA
  - Setting appropriate PEO and SLO which are relevant, measurable and meeting OBA requirements
  - Avoiding low outcome standards
  - Obtaining support from top management to institute outcomes-based teaching and learning
  - Buying-in from faculty on the benefits of OBA and securing their commitments to implement the continuous quality improvement mechanism, particularly at individual course module

CHALLENGES IN OBA IMPLEMENTATION

- **Challenges to the education providers include**:
  - Training faculty on assessment and evaluation methods which support OBA
  - Instituting the continuous quality improvement mechanism as illustrated in Figure 1, and having the people and resources to monitor and effect the CQI loops
  - Obtaining support and feedbacks from the stakeholders
  - Having champions to lead, implement and prepare for OBA
  - Giving due recognition for contribution to OBA

Washington Accord – An Overview

Introduction

- The Washington Accord was formed in 1989
- International agreement among bodies responsible for accrediting engineering degree programs.
- It recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering.

Signatories

- Signatories have full rights of participation in the Accord
- Qualifications accredited or recognised by other signatories are recognised by each signatory as being substantially equivalent to accredited or recognised qualifications within its own jurisdiction.

WA Signatories

- **Australia** - Represented by Engineers Australia (*1989*)
- **Canada** - Represented by Engineers Canada (*1989*)
- **Chinese Taipei** - Represented by Institute of Engineering Education Taiwan (*2007*)
- **Hong Kong China** - Represented by The Hong Kong Institution of Engineers (*1995*)
- **India** - Represented by National Board of Accreditation (2014)
- **Ireland** - Represented by Engineers Ireland (*1989*)
- **Japan** - Represented by Japan Accreditation Board for Engineering Education (*2005*)
- **Korea** - Represented by Accreditation Board for Engineering Education of Korea (*2007*)
- **Malaysia** - Represented by Board of Engineers Malaysia (*2009*)
- **New Zealand** - Represented by Institution of Professional Engineers NZ (*1989*)
- **Russia** - Represented by Association for Engineering Education of Russia (*2012*)
- **Singapore** - Represented by Institution of Engineers Singapore (*2006*)
- **South Africa** - Represented by Engineering Council of South Africa (*1999*)
- **Sri Lanka** - Represented by Institution of Engineers Sri Lanka (2014)
- **Turkey** - Represented by MUDEK (*2011*)
- **United Kingdom** - Represented by Engineering Council UK (*1989*)
- **United States** - Represented by Accreditation Board for Engineering and Technology (*1989*)

Provisional Status

- **Bangladesh** - Represented by Board of Accreditation for Engineering and Technical Education
- **China** - Represented by China Association for Science and Technology
- **Pakistan** - Represented by Pakistan Engineering Council
- **Philippines** - Represented by Philippine Technological Council
- **Peru** - Represented by ICACIT

Provisional Status

- **Organisations holding provisional status** have been identified as having qualification accreditation or recognition procedures that are potentially suitable for the purposes of the Accord;
- These organisations are further developing those procedures with the goal of achieving signatory status in due course;
- Qualifications accredited or recognised by organisations holding provisional status are not recognised by the signatories.

RECOGNITION OF EQUIVALENCY OF ACCREDITED ENGINEERING EDUCATION PROGRAMS

- Agreement on criteria, policies and procedures used by the signatories in accrediting engineering academic programs are comparable;
- Accreditation decisions rendered by one signatory are acceptable to the other signatories;
- Implementation of, best practice, as agreed from time to time amongst the signatories, for the academic preparation of engineers;
- Mutual monitoring and information exchange, including:
  - regular communication and sharing of information concerning their accreditation criteria, systems, procedures, manuals, publications and lists of accredited programs;
  - invitations to observe accreditation visits; and
  - invitations to observe meetings of any boards and / or commissions responsible for implementing key aspects of the accreditation process, and meetings of the governing bodies of the signatories.

Admission of new signatories

- The admission of new signatories to the Accord will require the unanimous approval of the existing signatories.
- Preceded by a prescribed period of provisional status, during which the accreditation criteria and procedures established by the applicant, and the manner in which those procedures and criteria are implemented, will be subject to comprehensive examination.
- Applicants for provisional status must be nominated by two of the existing signatories, and will be accepted only through a positive vote by at least two-thirds of the existing signatories.

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

"[SUTD] is a university which is linked up with MIT and Zhejiang University in China and these are very eminent institutions. These linkages will provide the students with not only a very high quality academic input, but also connections to two vibrant economies – the United States with its entrepreneurial and dynamic economic culture and China, a vibrant emerging economy."

Singapore Prime Minister Lee Hsien Loong

Publicly funded. Globally connected. Boldly designed.

Not a conventional university.

"We're trying to provide an environment [in SUTD] where boundary-crossing is the norm. Crossing boundaries between disciplines, crossing boundaries between countries, and crossing boundaries between the university and industry."

Prof Susan Hockfield, President, MIT

"It is the destiny of the 21st century. If you want to be a world-class university, you have to have international collaborations."

Prof Yang Wei, President, Zhejiang University

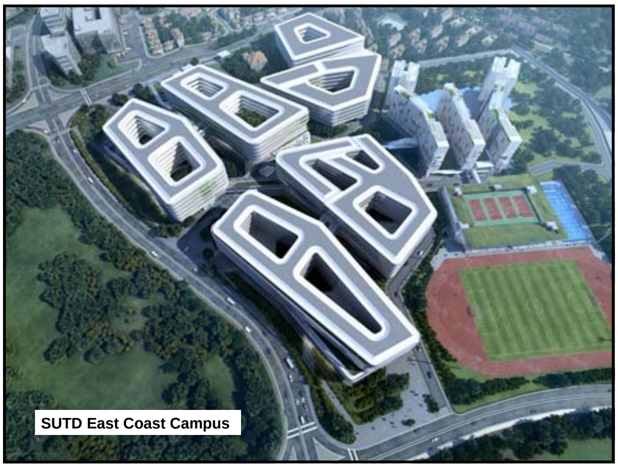
News › Education › Highereducation

The MIT factor: celebrating 150 years of maverick genius

The Massachusetts Institute of Technology has led the world into the future for 150 years with scientific innovations. Its brainwaves keep the US a superpower. But what makes the university such a fertile ground for brilliant ideas?

2011 Top 100 Chinese Universities

Rank	University
1	Zhejiang University
2	Peking University
3	Tsinghua University
4	Shanghai Jiao Tong University
5	Fudan University



CONCLUSION

- Independent accreditation important in quality assurance of engineering programmes;
- Outcomes-based accreditation framework for quality assurance of global engineering education.
- Outcomes-based assessment and evaluation systems must be put in place at the universities to implement CQI.
- Washington Accord, facilitates multi-lateral recognition of substantial equivalency of programmes by defining clearly the requirements of Graduate Attributes.