Attributes Expected of Engineering Graduates in WA and EU

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Introduction (1)

- Globalization of economy and Global problems
  (global warming, energy, food, natural resources, etc)

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- Mobility of professionals
- Liberalization of trade in goods and services and of investment

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- International Engineering Alliance (WA,DA,SA,EMF,APEC)
- Harmonization of engineering education

Introduction (2)

1. EU

- ✓ **Bologna Declaration** (or Bologna accords) to create the European higher education area by making academic degree standards and quality assurance standards more comparable and compatible throughout Europe by 2010
- ✓ 5-year Diploma ⇒ 3-year Bachelor, 2-year Master,
- ✓ Dublin descriptors
- ✓ EUR-ACE

2. Washington Accord

- ✓ First professional degree for professional engineer
- ✓ Difference between Engineering (WA) and Technologist education (SA) ?
- ✓ No comparison between BA and MA
- ✓ How to harmonize EUR-ACE ?

Introduction (3)

EUR-ACE

- **Germany , UK , France, Portugal, Italy, Ireland, Romania, Russia (SEFI, FEANI)**
- **A common European quality label (the EUR-ACE label) to national engineering accreditations agencies.**
- **Promotion of establishment of a new national (or regional) agency.**
- **ENAEE (European Network for Accreditation of Engineering Education) promotes the EUR-ACE implementation project and establishes a fee policy for self-supporting.**

‘Dublin’ descriptors (2004)
Differentiating between cycles(1)

Cycle	Knowledge and understanding
Bachelor	[is] supported by advanced text books [with] some aspects informed by knowledge at the forefront of their field of study
Master	provides a basis or opportunity for originality in developing or applying ideas often in a research context
Doctorate	[includes] a systematic understanding of their field of study and mastery of the methods of research* associated with that field..

http://www.jointquality.nl/content/descriptors/CompletesetDublinDescriptors.doc

IEA
Graduate Attributes: Definition

- A set of individually assessable set of outcomes

–Outcomes: components indicative of graduate's potential competency

- Clear, succinct statements of expected capability, qualified by range statements

Graduate Attributes: Objectives

- To define the attributes of a WA, SA & DA graduate in terms of competencies/outcomes
- To guide Signatories, Provisional members and intending Provisional members developing outcomes based criteria
- Support bodies developing accreditation systems
- To adequately distinguish the engineer, technologist and technician attributes

Graduate Attributes: Limitations

- Not intended to constitute an "international standards"
- Provide a point of reference for substantially equivalent accredited qualifications
- " Graduate " does not imply degree only

Comparison 1. Academic Education

IEA	Differentiating Characteristic	Educational depth and breadth
	WA	Completion of an accredited program of study typified by 4 years or more of post-secondary study.
	SA	Completion of an accredited program of study typified by 3 years or more of post-secondary study.
EUR-ACE	Common statements	
	1st cycle	3 years
	2nd cycle	1-2 years

2. Knowledge of Engineering Sciences

IEA	Differentiating Characteristic	Breadth and depth of education and type of knowledge, both theoretical and practical
	WA	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.
	SA	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to defined and applied engineering procedures, processes, systems or methodologies.
EUR-ACE	Common statements	The underpinning knowledge and understanding of science, mathematics and engineering fundamentals are essential to satisfy the other programme outcomes. Graduates should demonstrate their knowledge and understanding of their engineering specialization and also of the wider context of engineering
	1st cycle	Should have: - Knowledge and understanding of the scientific and mathematical principles underlying their branch of engineering - a systematic understanding of the key aspects and concepts of their branch of engineering - coherent knowledge of their branch of engineering -awareness of the wider multidisciplinary context of engineering
	2nd cycle	Should have: -an in depth knowledge and understanding of the principles of their branch of engineering - a critical awareness of the forefront of their branch

3. Problem Analysis

	Differentiating Characteristic	Complexity of analysis
IEA	WA	Identify, formulate, research literature and solve *complex* engineering problems reaching substantiated conclusions using first principles of mathematics and engineering sciences.
	SA	Identify, formulate, research literature and solve *broadly-defined* engineering problems reaching substantiated conclusions using analytical tools appropriate to their discipline or area of specialisation.
EUR-ACE	1st cycle	Should have: -the ability to apply their knowledge and understanding to identify, formulate and solve engineering problems using established methods - the ability to apply their knowledge and understanding to analyse engineering products, processes and methods - the ability to select and apply relevant analytic and modelling methods
	2nd cycle	Should have: -the ability to solve problems that are unfamiliar, incompletely defined and have competing specifications -the ability to formulate and solve problems in new and emerging areas of their specialisation -the ability to use their knowledge and understanding to conceptualise engineering models systems and processes -the ability to apply innovative methods in problem solving

4. Design/ development of solutions

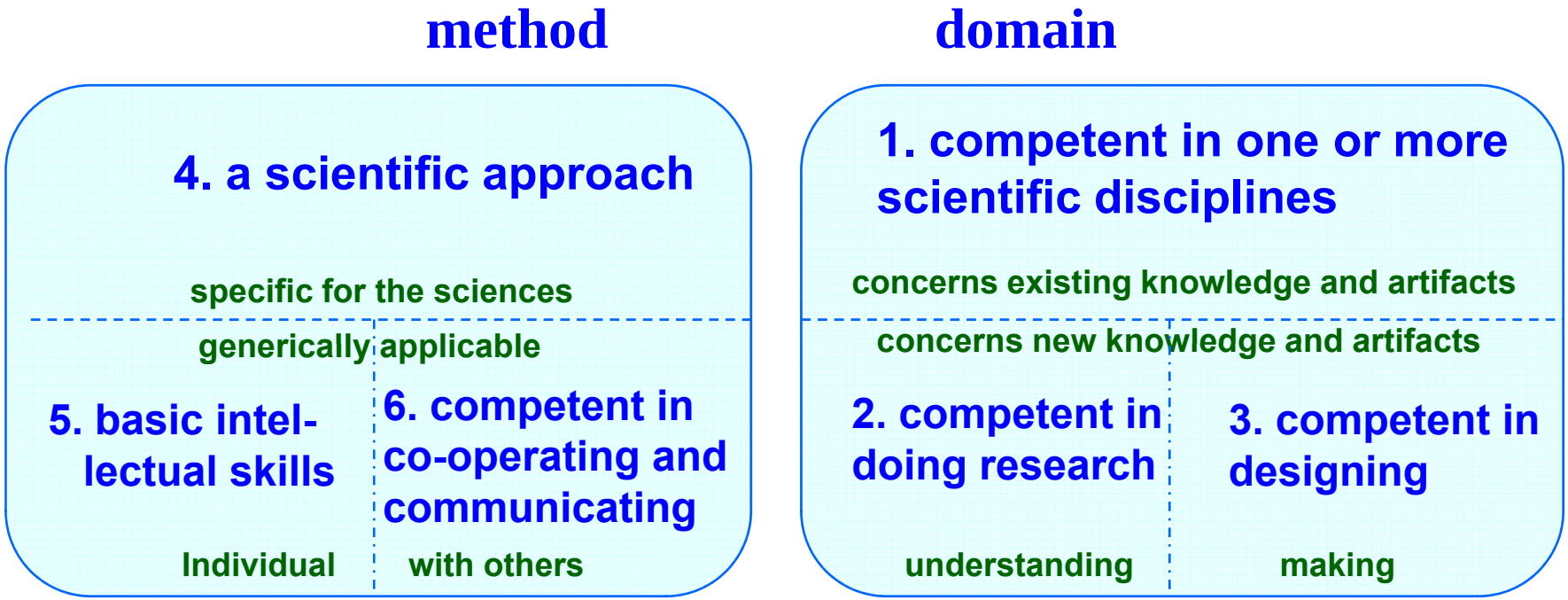
IEA	WA	Design solutions for *complex* engineering problems and *design* systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
	SA	Design solutions for *broadly- defined* engineering 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.
EUR-ACE	1st cycle	Should have: -the ability to apply their knowledge and understanding to develop and realize designs to meet defined and specified requirements - an understanding of design methodologies and an ability to use them
	2nd cycle	Should have -an ability t use their knowledge and understanding to design solutions to unfamiliar problems, possibly involving other disciplines - an ability to use creativity to develop new and original ideas and methods - and ability to use their engineering judgment to work with complexity, technical uncertainty and incomplete information

Range of Problem Solving (IEA, no in EUR-ACE) (1)

	Attribute	Complex Problems	Broadly-defined Problems
1	Preamble	Engineering problems which cannot be resolved without in-depth engineering knowledge and having some or all of the following characteristics:	Engineering problems having some or all of the following characteristics:
2	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues	Involve a variety of factors which may impose conflicting constraints
3	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	Can be solved by application of well-proven analysis techniques
4	Depth of knowledge required	Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach	Requires knowledge of principles and applied procedures or methodologies
5	Familiarity of issues	Involve infrequently encountered issues	Belong to families of familiar problems which are solved in well-accepted ways;

Range of Problem Solving (2)

	Attribute	Complex Problems	Broadly-defined Problems
6	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering	May be partially outside those encompassed by standards or codes of practice
7	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs	Involve several groups of stakeholders with differing and occasionally conflicting needs
8	Consequences	Have significant consequences in a range of contexts	Have consequences which are important locally, but may extend more widely
9	Interdependence	Are high level problems possibly including many component parts or sub-problems	Are parts of, or systems within complex engineering problems



Areas of competence of a university graduate

Delft Univ., Eindhoven U.T., U.Twente

http://www.jointquality.nl/content/descriptors/AC_English_Gweb.pdf

1. Competent in one or more scientific disciplines.

Bachelor	Master
Understands the knowledge base of the relevant fields (theories, methods, techniques). [knowledge,skill]	Has a thorough mastery of parts of the relevant fields extending to the forefront of knowledge (latest theories, methods, techniques and topical questions). [k,s]
Understands the structure of the relevant fields, and the connections between sub-fields. [k,s]	Looks actively for structure and connections in the relevant fields. [k,s,attitude]
Has knowledge of and some skill in the way in which truth-finding and the development of theories and models take place in the relevant fields. [k,s]	Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [k,s,a]
Has knowledge of and some skill in the way in which interpretations (texts, data, problems, results) take place in the relevant fields. [k,s]	Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [k,s,a]
Has knowledge of and some skill in the way in which experiments, gathering of data and simulations take place in the relevant fields. [k,s]	Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [k,s,a]
Has knowledge of and some skill in the way in which decision-making takes place in the relevant fields. [k,s]	Has the skill and the attitude to apply these methods independently in the context of more advanced ideas or applications. [k,s,a]
Is aware of both the presuppositions of the standard methods and their importance. [k,s,a]	Is able to reflect on standard methods and their presup-positions; is able to question these; is able to propose adjustments, and to estimate their implications. [k,s,a]
Is able (with supervision) to spot gaps in his /her own knowledge, and to revise and extend it through study.[k,s]	Idem, independently. [k,s,a]

2. Competent in doing research(*The development of new knowledge and new insights in a purposeful and methodical way)*

Bachelor	Master
Is able to reformulate ill-structured research problems. Also takes account of the system boundaries in this. Is able to defend the new interpretation against involved parties. [ksa]	Idem, for problems of a more complex nature. [ksa]
Is observant, and has the creativity and the capacity to discover in apparently trivial matters certain connections and new viewpoints. [ksa]	Idem, and is able to put these viewpoints into practice for new applications. [ksa]
Is able (with supervision) to produce and execute a research plan. [ks]	Idem, independently. [ks]
Is able to work at different levels of abstraction. [ks]	Given the process stage of the research problem, chooses the appropriate level of abstraction. [ksa]
Understands, where necessary, the importance of other disciplines (interdisciplinarity). [ka]	Is able, and has the attitude to, where necessary, draw upon other disciplines in his or her own research. [ksa]
Is aware of the changeability of the research process through external circumstances or advancing insight. [ka]	Is able to deal with the changeability of the research process through external circumstances or advancing insight. Is able to steer the process on the basis of this. [ksa]
Is able to assess research within the discipline on its usefulness. [ks]	Is able to assess research within the discipline on its scientific value. [ksa]
Is able (with supervision) to contribute to the development of scientific knowledge in one or more areas of the disciplines concerned. [ks]	Idem, but independently. [ksa]

3.Competent in designing *(a synthetic activity aimed at the realization of new or modified artifacts or systems, with the intention of creating value in accordance with predefined requirements and desires (e.g. mobility, health))*

Bachelor	Master
Is able to reformulate ill-structured design problems. Also takes account of the system boundaries in this. Is able to defend this new interpretation against the parties involved. [ksa]	Idem, for design problems of a more complex nature. [ksa]
Has creativity and synthetic skills with respect to design problems. [ksa]	Idem. [ksa]
Is able (with supervision) to produce and execute a design plan. [ks]	Idem, independently. [ks]
Is able to work at different levels of abstraction including the system level. [ks]	Given the process stage of the design problem, chooses the appropriate level of abstraction. [ksa]
Understands, where necessary, the importance of other disciplines (interdisciplinarity). [ks]	Is able, and has the attitude, where necessary, to draw upon other disciplines in his or her own design. [ksa]
Is aware of the changeability of the design process through external circumstances or advancing insight. [ka]	Is able to deal with the changeability of the design process through external circumstances or advancing insight. Is able to steer the process on the basis of this. [ksa]
Is able to integrate existing knowledge in a design. [ks]	Is able to formulate new research questions on the basis of a design problem. [ks]
Has the skill to take design decisions, and to justify and evaluate these in a systematic manner. [ks]	Idem. [ksa]

JABEE Criterion1:Educational objectives (Bachelor programs)

(a) An ability and intellectual foundation to consider issues from a global and multilateral viewpoint.

(b) Understanding of the effects and impact of engineering on society and nature, and of engineers' social responsibility (engineering ethics).

(c) Knowledge of mathematics, natural sciences and information technology and an ability to apply such knowledge.

(d) Specialized engineering knowledge in each applicable field, and an ability to apply such knowledge to provide solutions to actual problems.

(e) Design abilities to organize comprehensive solutions to societal needs by exploiting various disciplines of science, engineering and information.

(f) Japanese-language communication skills including methodical writing, verbal presentation and debate abilities, as well as basic skills for international communication.

(g) An ability to carry on learning on an independent and sustainable basis.

(h) An ability to implement and organize works systematically under given constraints.

Criterion 1: Establishment and Disclosure of Learning and Educational Objectives (JABEE, Master)

For the purpose of fostering highly skilled engineers being aware of their social responsibility and capable of domestically and internationally contributing to social welfare, the program must establish its own specific learning and educational objectives that are more advanced than those of Bachelor's courses and incorporate the knowledge and abilities described in items (i) - (v) below. The learning and educational objectives must be disclosed widely on and off campus and must be known to the faculty members and students involved in the program.

i) Deeper knowledge of the fundamental principles and methodologies of the relevant engineering field and an ability to apply this knowledge to actual problems.
ii) Cross-discipline knowledge and awareness of related engineering fields.
Iii) An ability to analyze engineering problems and to define and resolve issues.
Iv) Survey and research abilities, including conducting documentary and field surveys, setting hypotheses, and testing hypotheses.
V) Social and interpersonal skills, including communication and leadership ability.

Future works by IEA

- ✓ A detailed comparison of the EUR-ACE and IEA criteria in order to identify the differences in scope and standards
- ✓Development of a glossary of terms and words
- ✓Further comparison work against others ;ECUK, RAEE, and the WA/EUR-ACE by Mr.Ian Freeston
- ✓Discussions between the IEA and ENAEE
- ✓Interpretation of EUR-ACE first cycle and SA objectives
- ✓A common descriptive language and glossary
- ✓A common standard or failing the development of a connecting document

Concluding remarks

- ✓ From limited document, it seems WA graduate attributes(GA) are equivalent to Master GA in EU
- ✓ No problems if they request to recognize Master programs as the WA first degree.
- ✓ Problem: The real GA of WA bachelor programs are equivalent to the Master GA ?
- ✓ Need to compare the real outcomes of our own programs with those of other countries.
- ✓ How to evaluate the outcomes ?
- ✓ Abandon the strict equivalency ?