Developing an Engineering Problem Level Descriptor for Accreditation in Korea

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Graduate Attributes & Gap Analysis

- **Demonstration of compliance**
  - **GA's are exemplar statements to help ensure substantial equivalence amongst signatories**
  - **Compare Outcome Statements with "Knowledge Profile", "Problem-solving Level" and "Graduate Attributes"**
    - **Identify areas of compliance**
    - **Identify areas of non-compliance**

WA Knowledge Profile

- A systematic, theory-based natural sciences
- Conceptually-based mathematics, numerical analysis….
- Theory-based engineering fundamentals
- Engineering specialist knowledge
- Knowledge that supports engineering design
- Knowledge of engineering practice (technology)
- Engineering in society, ethics, public safety, etc.
- Research literature of the discipline.

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WA Complex Engineering Problems

- Wide-ranging or conflicting technical, engineering issues
- No obvious solution and require abstract thinking, originality in analysis to formulate suitable models
- Research-based knowledge and allows a fundamentals-based, first principles analytical approach
- Involve infrequently encountered issues
- Outside problems encompassed by standards and codes of practice
- Diverse groups of stakeholders with widely varying needs
- Significant consequences in a range of contexts
- High level including many component parts or sub-problems

Complex Engineering Problems

In the context of both Graduate Attributes and Professional Competencies:			
Attribute	***Complex Engineering Problems* have characteristic WP1 and some or all of WP2 to WP7:**	***Broadly-defined Engineering Problems* have characteristic SP1 and some or all of SP2 to SP7:**	***Well-defined Engineering Problems* have characteristic dP1 and some or all of DP2 to DP7:**
Knowledge required	**WP1:** cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach;	**SP1:** cannot be resolved without engineering knowledge at the level of one or more of SK 4, SK5, and SK6 supported by SK3 with a strong emphasis on the application of developed technology;	**DP1:** can be resolved using limited theoretical knowledge defined in DK3 and DK4 but normally requires extensive practical knowledge as reflected in DK5 and DK6;
Range of conflicting requirements	**WP2:** Involve wide-ranging or conflicting technical, engineering and other issues	**SP2:** Involve a variety of factors which may impose conflicting constraints	**DP2:** Involve several issues, but with few of these exerting conflicting constraints
Depth of analysis required	**WP3:** Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	**SP3:** Can be solved by application of well-proven analysis techniques	**DP3:** Can be solved in standardised ways
Familiarity of issues	**WP4:** Involve infrequently encountered issues	**SP4:** Belong to families of familiar problems which are solved in well-accepted ways	**DP4:** Are frequently encountered and thus familiar to most practitioners in the practice area
Extent of applicable codes	**WP5:** Are outside problems encompassed by standards and codes of practice for professional engineering	**SP5:** May be partially outside those encompassed by standards or codes of practice	**DP5:** Are encompassed by standards and/or documented codes of practice
Extent of stakeholder involvement and conflicting requirements	**WP6:** Involve diverse groups of stakeholders with widely varying needs	**SP6:** Involve several groups of stakeholders with differing and occasionally conflicting needs	**DP6:** Involve a limited range of stakeholders with differing needs
Interdependence	**WP 7:** Are high level problems including many component parts or sub-problems	**SP7:** Are parts of, or systems within complex engineering problems	**DP7:** Are discrete components of engineering systems
In addition, in the context of the Professional Competencies			
Consequences	**EP1:** Have significant consequences in a range of contexts	**TP1:**Have consequences which are important locally, but may extend more widely	**NP1:** Have consequences which are locally important and not far-reaching
Judgement	**EP2:** Require judgement in decision making	**TP2:** Require judgement in decision making	

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Graduate Attributes of WA

- **WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization ……to the solution of *complex engineering problems*.**
- **WA3: Design solutions for *complex engineering problems* and design systems, components …… with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.**
- **WA5: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, ….to *complex engineering problems*, ……**

Graduate Attributes of WA

- **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***
- **WA10: Communicate effectively on complex engineering activities with the engineering community and with society at large ……..**
- **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**

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Gap Analysis

- **Graduate Attributes vs. Program Outcomes**

  (ABEEK's Gap Analysis of 2012)

  (A) Knowledge Profile → No problem

  (B) Level of Problem Solving : None exists!

  → Adopt "*Complex Engineering Problems*" or develop an alternative level descriptor

  (C) Graduate Attributes → Minor wording change

  (project management, research, sustainability)

Gap Analysis

- **An Example**

PO1 : An ability to apply knowledge of mathematics, basic sciences, engineering, and information technology

vs.

GA1: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of *complex engineering problems*

→Adopt or Develop alternative level descriptor

for inclusion in the new PO's

A Survey

- **Faculty survey on direct use of WA Complex Engineering Problems in Korea**

→ **Uncomfortable with attributes such as stakeholder involvement, conflicting requirements, applicable codes, consideration of consequences in a broad range of societal issues**

→ **Not familiar with some of the terms contained in WA *Complex Engineering Problems***

→ **Assessment consistency deemed difficult to achieve**

→ **Some redundancies/overlap in WA statements**

Professional practice vs. Academic orientation

Development of a Level Descriptor

- **Develop a customized level descriptor more suitable for local use: *Engineering Problems***

→ **Applicable to all engineering disciplines**

→ **Provide sufficient distinction between WA, SA and DA**

→ **Use terms and concepts familiar to local practice in engineering education and accreditation**

→ **Simple, non-overlapping attribute boundaries**

→ **Specify level for hard skills PO's**

→ **Be concise**

A Level Descriptor: Engineering Problems

- **Non-overlapping set of 4 required attributes of *Engineering Problems***
  - **Breadth of knowledge**
  - **Depth of knowledge**
  - **Depth of analysis (Open problem)**
  - **Degree of authenticity (Realistic problem)**

A Level Descriptor

- **Breadth of Knowledge**

  1. Mathematics, basic sciences, computing and engineering fundamentals that support the discipline
  2. Comprehensive knowledge applicable to the discipline

- **Depth of Knowledge**

  1. A theory-based understanding of engineering fundamentals and discipline-specific knowledge
  2. Analytical methodology based on relevant theories and principles

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A Level Descriptor

- **Depth of Analysis (Open problem)**
  1. Have no obvious solution which allows diverse perspectives and approaches to bear multiple possible solutions
  2. Involve first principles based analytical thinking and abstraction in model formulation
- **Degree of Authenticity (Realistic problem)**
  1. Involve wide-ranging or conflicting technical and engineering issues
  2. Involve diverse realistic constraints

Comparison with WA Complex Engineering Problems

- **Depth of knowledge**
- **Range of conflicting requirement**
- **Depth of analysis**
- **Familiarity of issue**
- Extent of applicable codes
- Extent of stakeholder involvement, varying needs
- **Interdependence**

Comparison with Complex Engineering Problems

- **Wide-ranging or conflicting technical, engineering issues**
- **No obvious solution and require abstract thinking, originality in analysis to formulate suitable models**
- **Research-based knowledge and allows a fundamentals-based, first principles analytical approach**
- **Involve infrequently encountered issues**
- Outside problems encompassed by standards and codes of practice
- Diverse groups of stakeholders with widely varying needs
- Significant consequences in a range of contexts
- **High level including many component parts or sub-problems**

Program Outcomes: Before 2015

Criterion 2: Program Outcomes (KEC2005)

(1) An ability to apply knowledge of mathematics, basic science, engineering, and information technology
(2) an ability to design and conduct experiments, as well as to analyze and interpret data
(3) an ability to devise a system, component, or process to meet desired needs within realistic constraints
(4) an ability to identify, formulate, and solve engineering problems
(5) an ability to use techniques, skills, and engineering tools necessary for engineering practice
(6) an ability to function in multi-disciplinary teams
(7) an ability to communicate effectively
(8) a recognition of the need for, and an ability to engage in life-long learning
(9) a broad understanding of the impact of engineering solutions in economic, environmental, and societal context
(10) a knowledge of contemporary issues
(11) an understanding of professional and ethical responsibilities
(12) an understanding of other cultures and an ability to engage in international cooperation

Program Outcomes: Since 2015

Criterion 2: Program Outcomes (KEC2015)

(1) An ability to apply knowledge of mathematics, basic sciences, engineering, and information technology to the solution of ***engineering problems***

(2) an ability to analyze data, and verify facts and hypotheses through experiments

(3) an ability to define and formulate ***engineering problems***

(4) an ability to apply latest information, research-based knowledge and appropriate tools to the solution of ***engineering problems***

(5) an ability to design a system, component, or process to meet desired needs within realistic constraints

(6) an ability to contribute to project team output in the solution of ***engineering problems***

(7) an ability to communicate effectively under diverse situations

(8) an ability to understand the impact of engineering solutions in the context of health and safety, economics, environment and sustainability

(9) an ability to understand professional ethics and social responsibilities

(10) a recognition of the need for, and an ability to engage in life-long learning in the context of technological change

Implementation

- **Introduced in 2015; does not affect the accreditation decision until 2018**
- **Capstone design problems expected to comply with all four attributes of *Engineering Problems***
- **Programs self-evaluate the degree of compliance of capstone design projects with each of the four attributes of *Engineering Problems***
- **Further clarification of various terms may be needed**