Improving learning outcomes assessment in Engineering Education

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Before...

*What will we teach our students?*
Why change?...

- Demand for new skills and competences
- Mobility and recognition
- Quality approach and accreditation

THE FOCUS IS ON THE STUDENTS!

http://taloe.up.pt
What should the students learn?

What do we hope students will learn?

How do we know what students have learned?
Learning Outcomes

Learning outcomes are statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of learning.

(AHELO - Assessment of Higher Education Learning Outcomes by OECD)

Assessment

Assessment: Any procedure used to estimate student learning for whatever purpose.

(Brown et al)
Alignment: The level of correspondence between objectives, instruction and assessment.

(Anderson et al)
Simple problem...?
Distillation: Process to obtain the essence from the rough products (of your brains)

(STOLEN FROM THE PRESIDENT)
Learning Outcomes in Engineering

- EUR-ACE: European quality label for engineering degree programmes
- ABET: Accreditation Board for engineering and Technology
- CDIO: Conceiving, Designing, Implementing, Operating
- EQF: European Qualification Framework (general)
Programme Outcomes @ EUR-ACE

- Knowledge and understanding
- Engineering Analysis
- Engineering Design
- Investigations
- Engineering Practice
- Making Judgements
- Communication and Team-working
- Lifelong Learning

http://taloe.up.pt
ALIGNMENT

General

POs
EUR-ACE

General assessment methods

Specific

Course and Programme LOs

Real Assessment tasks

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Aligning Learning Outcomes and Assessment

- POs in EURACE
- LOs in programmes
- LOs in courses
- ALIGNMENT (BLOOM)
- Assessment methods

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How to obtain the right evidence of knowledge, understanding, skills and abilities?

- Aligning assessment to EURACE Programme Outcomes
  - Multiple choice questions
  - Short Answer Questions
  - Problems
  - Essays
  - Practical work
  - Reflective practice
  - (…)

http://taloe.up.pt
Assessment categories

- Multiple choice questions
- Short Answer Questions
- Problems
- Essays
- Practical work
- Reflective practice
SAQs

• Select crucial evidence
• Explain methods, procedures and relationships
• Present arguments
• Describe limitations of data
• Formulate valid conclusions
• Identify assumptions
• Formulate hypothesis
• Formulate action plans
<table>
<thead>
<tr>
<th>SAQ 02</th>
<th>Explain methods, procedures and relationships</th>
</tr>
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</table>

The student is asked to describe and explain methods, procedures and relationships. The student will have to recall and select information about the topic and explain and analyse as requested.

<table>
<thead>
<tr>
<th>Knowledge type</th>
<th>Factual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conceptual</td>
</tr>
<tr>
<td></td>
<td>Procedural</td>
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<table>
<thead>
<tr>
<th>Cognitive process</th>
<th>Remember: recalling</th>
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<tbody>
<tr>
<td></td>
<td>Understand: explaining</td>
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<td>Analyse: differentiating, organizing</td>
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Based on the work by Brown et al.
Programme Outcomes @ EUR-ACE

- Knowledge and understanding
- Engineering Analysis
- Engineering Design
- Investigations
- Engineering Practice
- Making Judgements
- Communication and Team-working
- Lifelong Learning

http://taloe.up.pt
**Description by EUR-ACE**

The underpinning knowledge and understanding of science, mathematics and engineering is essential to satisfying the other programme outcomes. Graduates should demonstrate their understanding of their engineering specialisation, and also of the wider context of engineering.

**First Cycle** graduates 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 including some at the forefront of the branch;
- awareness of the wider multidisciplinary context of engineering.

**Second Cycle** graduates 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.

**Analysis**

The description of this LO uses the terms knowledge and understanding that indicate two main categories of cognitive processes: remember and understand. The description does not give indication of the specific cognitive processes. Additionally, there is some indication of the other cognitive categories. Coherent knowledge is related with analyse, specifically organizing knowledge. Critical awareness is related with critiquing.

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<td>EUR-ACE 2</td>
<td>Engineering analysis</td>
<td></td>
<td></td>
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**Description by EUR-ACE**

Graduates should be able to solve engineering problems consistent with their level of knowledge and understanding, and which may involve **considerations from outside their field of specialisation**. Analysis can include the **identification of the problem, clarification of the specification, consideration of possible methods of solution, selection of the most appropriate method, and correct implementation**. Graduates should be able to use a variety of methods, including mathematical analysis, computational modelling, or practical experiments, and should be able to recognise the importance of societal, health and safety, environmental and commercial constraints.

**First Cycle** graduates 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.

**Second Cycle** graduates 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.
**Analysis**

The first part of the description gives indication that the types of knowledge included in this LO are conceptual and procedural. In terms of cognitive processes it is possible to identify several processes in the full scope of categories. In Remember, the student should be able to recognize the types of problems and recall procedural knowledge. In Understand, the student should be able to interpret the specifications, classify the problem, compare different methods and infer a conclusion. In apply, the learner should be able to execute procedures to solve simple problems and implement solution for more complex problems. In terms of analysis, students may have to select from different methods and for more complex problems they should organise several methods in a procedure.

From the analysis of the detailed descriptors it is possible to identify some other cognitive processes. The ability to formulate problems in new and emerging areas may be interpreted as generating hypothesis. Constructing a model is related with understanding and explaining, or if more complex, may be seen as designing. It will be necessary that the students make judgments as they proceed in developing the solution to the problem.

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<td>Apply: executing, implementing</td>
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<td></td>
<td>Evaluate: judging</td>
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<td></td>
<td>Create: generating, planning</td>
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</tbody>
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Aligning Learning Outcomes and Assessment

- POs in EURACE
- LOs in programmes
- LOs in courses
- Assessment methods
- BLOOM DISTILLATION
- ALIGNMENT
<table>
<thead>
<tr>
<th>Outcome Element</th>
<th>Cognitive/Affective Domain</th>
<th>Attributes</th>
</tr>
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</table>
| **Design Experiments, continued** | Application | • Can use existing theory/history to design an experiment  
• Chooses the measure(s) of effectiveness by which the outcome or the alternative will be evaluated – cost, quality, value, time to complete, feasibility  
• Formulates the control and evaluating alternatives of the experiment  
• Develops contingency plans  
• Applies constraints and assumptions into experimental design  
• Determines the data that are appropriate to collect  
• Specifies and justifies the assumptions given test conditions |
| | Analysis | • Predicts experimental uncertainties |
| | Synthesis | • Seeks information for experiment from multiple sources |
| | Evaluation | • Valuation | • Accepts the limitations and extensions that an experiment built can be used to represent the system |
| **Conduct Experiments** | Knowledge | • Aware of measurement errors in instrumentation, human, environment  
• Anticipates and minimizes experimental disruptions via pilot study |
| | Comprehension | • Acknowledges possible disruptions to existing surroundings and operations  
• Uses appropriate measurement techniques to collect data  
• Facilitates use of modern data collection techniques (computer for data logging)  
• Follows ethical protocols when collecting data  
• Documents collection procedures such that experiment may be repeated  
• Anticipates and minimizes data errors via pilot study |
| | Application | • Analysis |
| | Synthesis | • Evaluation |
| | Interpret Data | • Valuation |
| **Analyze Data** | Knowledge | • Can select and explain different methods of analysis (descriptive and inferential) and depth of the analysis needed  
• Can identify different audiences and their analysis/summary needs  
• Can identify artifacts/confounding elements that may result  
• Uses appropriate tools to analyze data  
• Selects and uses appropriate, self-explanatory graph formats for data  
• Prepares analysis such that results can be replicated  
• Can apply statistical procedures  
• Investigates possible artifacts with a balance of costs associated with the analysis  
• Organizes information into meaningful categories |
| | Comprehension | • Analysis |
| | Application | • Synthesis |
| | Analysis | • Interpret Data |
| | Synthesis | • Valuation |
Ask for Assessment Advice

Step 1: Choose the learning outcome you want your students to achieve. You can write the learning outcome in the box below.

Students will be able to explain the function, structure and components of the musculoskeletal system

Step 2: Please select from one or more of the tabs below the verb or the verbs (maximum 3) that better describes the Learning Outcome:

- Remember
- Understand
- Apply
- Analyze
- Evaluate
- Create

- Interpreting – Changing from one form of representation to another
- Exemplifying – Finding a specific example or illustration of a concept or principle
- Classifying – Determining that something belongs to a category
- Summarizing – Abstracting a general theme or a major point
- Inferring – Drawing a logical conclusion from presented information
- Comparing – Detecting correspondences between two ideas, objects or the like
- Explaining – Constructing a cause-and-effect model of a system

Check assessment methods
ALOA -> TALOE - > CALOHEE

ALOA MODEL
TALOE
TIME TO ASSESS LEARNING OUTCOMES IN E-LEARNING
Tuning CALOHEE

http://taloe.up.pt
Thank you!

rfalcao@unl.pt

http://taloe.up.pt
### Alignment criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match</td>
<td>LO statement = TLA = assessment</td>
</tr>
<tr>
<td>Emphasis</td>
<td>LOs have different levels of importance</td>
</tr>
<tr>
<td>Coverage</td>
<td>The content of the course should be covered</td>
</tr>
<tr>
<td>Precision</td>
<td>A complex LO may include different competences with different values.</td>
</tr>
</tbody>
</table>