A BRIEF GUIDE TO WRITING LEARNING OUTCOMES

Why work on learning outcomes?

EPFL's dual recognition of its degrees (OAQ-CTI) requires that all programmes define the knowledge and technical and transversal skills that graduates should acquire at the end of their education. Further accreditation, such as ABET would also require of such effort. The list of skills, competencies and knowledge to be developed through a programme is commonly talked about as 'learning outcomes'.

More generally, a learning outcomes approach to describing courses is now found in higher education throughout Europe and beyond:

- Learning outcomes help in planning the sequence of a programme by enabling planners to identify if all the required knowledge and skills are being addressed and in an appropriate order
- Student mobility becomes easier if everyone is clear as to what learning the student will achieve in a given course.

External bodies such as the CRUS and CTI acknowledge the progress made on defining the learning outcomes of some programmes at EPFL, most notably at the school of Mechanical Engineering (GM). The Life Sciences (SV) and Civil Engineering (GC) schools have also defined a series of learning outcomes for their programmes. This document takes examples from these programmes to illustrate the writing and defining of learning outcomes.

What does it mean to define the learning outcomes for a programme and for a course?

Working on learning outcomes is mainly an effort of making explicit what teachers already have in mind: ***What have the students learnt from this course?*** This document aims to provide tools and ideas to formulate the answer to this question.

Writing Course Learning Outcomes

One way of describing a course is to describe it in terms of the content that will be covered by the teacher. A learning outcomes approach, on the other hand, does not only describe the knowledge to be learned, but also the skills and attitudes to be acquired. It focuses on what students will be able to do, rather than on what the teacher will have covered.

A learning outcome is a clear statement of the minimum requirements to pass a course expressed in terms of what the student will be able to do.

A course will often have between five and fifteen learning outcomes depending on the nature of the course and its ECTS credit weighting.

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S. Isaac, R. Tormey, I. Le Duc, J.L. Ricci, N. Stainier.

Some examples of learning outcomes

The student will be able to:

- Construct and analyse a discrete-time model for a dynamic system
- Design mechatronic systems (choice of sensors, actuators, embedded systems)
- Describe simplified governing equations, such as the Bernouli or potential equations, their domain validity and apply them in appropriate situations
- Continue to work through difficulties or initial failures to find optimal solution
- Carry out a multi-criterion (technological, economic and environmental) analysis of design and production solutions
- Co-ordinate a team to develop, agree and deliver upon a work plan
- Model, analyse and optimize the internal logistics of a production and distribution system and the dynamic behaviour of a network of companies
- Write a scientific or technical report

1. Learning outcomes should be written in terms of what the student will be able to do, using words that describe student actions

- **Construct** and **analyse** a discrete-time model for a dynamic system
- **Co-ordinate** a team to develop, agree and deliver upon a work plan
- **Design** mechatronic systems (choice of sensors, actuators, embedded systems)
- **Carry out** a multi-criterion (technological, economic and environmental) analysis of design and production solutions
- **Write** a scientific or technical report

2. Learning outcomes describe minimum standards not the maximum goal

- If a learning outcome for a course says "Describe simplified governing equations, such as the Bernouli or potential equations, their domain validity and apply them in appropriate situations" then all students who receive a minimum passing standard (a grade '4') in course should be able to do that
- It should be made clear to students that those who expect to receive better grades should be able to do more than is stated in the learning outcomes
- Teachers may want to develop a "grade descriptor" document, identifying what is expected for someone to, for example, score a 5 or a 6 (the learning outcomes already describe what is expected for a grade 4); teachers can exercise their own judgement in defining these grade levels.

3. The learning outcomes approach goes beyond describing areas of knowledge to describing the depth of learning

Learning outcomes refer to not only to the ability to remember knowledge but also to the abilities to use higher order thinking skills such as applying, utilising, evaluating and creating knowledge.

Examples of learning outcomes which focus on lower order thinking skills (i.e., memorisation):

- **Explain** the operation of sensors, actuators and of the respective control algorithms
- **Illustrate** the biomechanical function of the different systems that form the human body
- **Describe** physical phenomena associated with compressibility
- **List** and explain the hygiene and safety rules applicable to biomechanical testing of biologic tissues

Examples of learning outcomes which focus on higher order thinking skills:

- **Determine if** a given flow can be treated as incompressible
- **Use an** order of magnitude analysis, to obtain the simplified equations describing lubrication and boundary layers
- **Construct** and **analyse** a discrete-time model for a dynamic system
- **Analyse** the energy and exergy efficiency of industrial energy systems
- **Evaluate** the methodological choices for the building of a model and validate the results with respect to the analysis and modelling objectives

Thinking skills are thought of as a hierarchy with "remember" being the simplest way of working with knowledge and "create" being the most advanced (this is called "Bloom's Taxonomy [Krathwohl, 2002]). Some examples of action terms commonly used with each level are included below.

Cognitive Level	
Higher cognitive Level (Evaluating and Creating)	Assess, construct, create, critique, design, develop [a rule, model or system], generalize, formulate, hypothesize, infer, propose, synthesize, systematize, theorize, argue, choose [an appropriate method], select [an appropriate material], critique, defend, evaluate, judge, justify, advice, formalize
Mid-range cognitive Level (Applying and Analyzing)	Apply, calculate, compute, conduct [an experiment], carry out, demonstrate, derive, use, implement, manipulate, modify, model, operate, perform, solve, analyze, categorize, compare, contrast, differentiate, discriminate, distinguish, explore, investigate, test, translate
Lower cognitive level (Knowing and Understanding)	Arrange, define, label, list, match, name, order, recognize, recall, restate, represent, draw, classify, complete, describe, discuss, establish, explain, present, express, identify, illustrate, quote, give an example

4. The learning outcomes also describes the breadth of learning

Learning outcomes for a course should include domain specific knowledge and skills and *can* also include some of the transversal or cross-cutting skills that we aspire for our graduates to have. For example:

Some examples of transversal learning outcomes
The student will be able to:

- Write a scientific or technical report
- Do a literature review and assess the state of the art
- Co-ordinate a team to develop, agree and deliver upon a work plan
- Continue to work through difficulties or initial failure to find optimal solution
- Document and communicate a project
- Plan activities in a way which makes optimal use of available time

Ideally, such transversal skills will be learned by students while learning their domain specific knowledge. For example, they will learn to plan their time effectively by having to manage the various requirements of a busy workload; they will learn to do a literature review by researching within courses. As with other skills, some guidance and support will need to be given to students as to how to master these skills.

Course descriptions will list both **domain learning outcomes** and can list **transversal learning outcomes**, where they are appropriate. Most learning outcomes at course level will be domain specific.

5. A course's learning outcomes correspond to one or more programme outcomes
-- expand and refer to CTI profile and competences with the graduate

Goals at a programme level are often quite general. Depending on the programme, they may be designed in order to ensure that the programme meets external accreditation requirements (e.g. CTI, ABET), and the needs of potential employers. At the same time, they will reflect the distinctive approach and strengths of EPFL.

- Learning outcomes for a course should typically be quite specific and should be assessable either directly or indirectly
- Limitations of examinations mean it will not always be possible to assess all learning outcomes in each course – teachers will often chose to assess a selection of learning outcomes that are most directly assessable and representative
- Learning outcomes define only the minimum passing requirements for a course – teachers will have freedom to design courses which meet these minimum requirements but also address additional or more complex ideas as they see fit.

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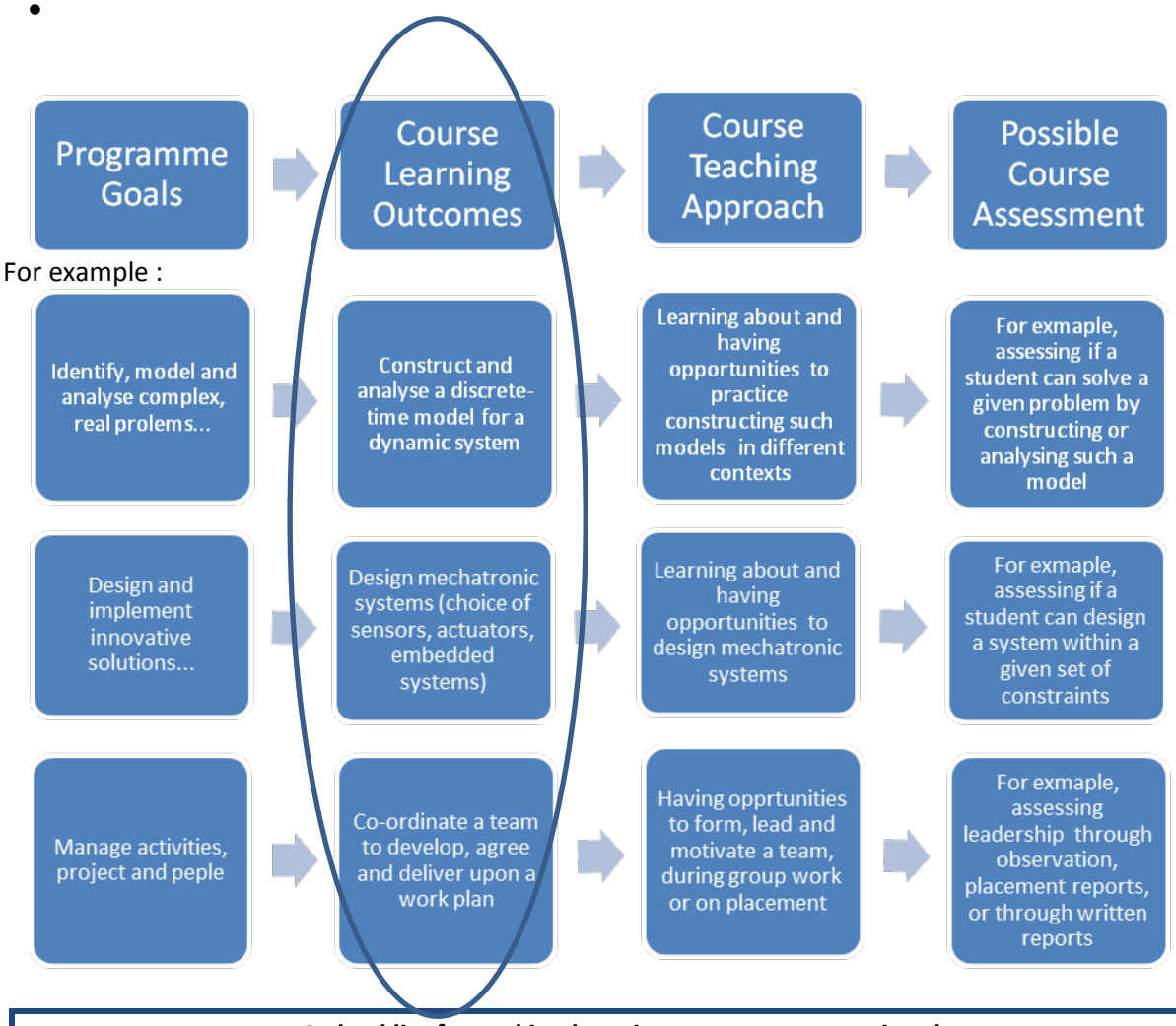

A checklist for making learning outcomes operational:

1. How will this learning outcome be assed?
2. What teaching method do I need to ensure that students have learned?
3. What feedback will students receive in terms of their progress in learning it?
4. How do I integrate such learning outcome in my course?
5. Will students apply this learning in another course or professional practice?

A learning outcomes checklist

Do…

Do write learning outcomes that are relatively short and precise: • Construct and analyse a discrete-time model for a dynamic system • List and explain the hygiene and safety rules applicable to biomechanical testing of biologic tissues • Illustrate the biomechanical function of the different systems that form the human body	☑
Do write learning outcomes that describe student actions • **Construct** and **analyse** a discrete-time model for a dynamic system • **Form** and **motivate** a team of people • **Design** mechatronic systems (choice of sensors, actuators, embedded systems)	☑
Do write learning outcomes that describe higher order thinking as well as those that describe memorisation • Use an order of magnitude analysis, to obtain the simplified equations describing lubrication and boundary layers **(Application)** • Construct and analyse a discrete-time model for a dynamic system **(Analysis, Creation)** • Analyse the energy and exergy efficiency of industrial energy systems **(Analysis)**	☑
Do write learning outcomes that can be assessed in some way	☑
Do write learning outcomes that reflect domain knowledge and skills and, where appropriate, also include some that reflect transversal skills	☑

Don't…

Don't write learning outcomes that do not refer to student action: • position vector; scalar product; dot product and angle between vectors • Principles and scope of ecology; ecosystems; cycles in nature; energy flows • Understand how concrete and metal interact in structures	☒
Don't write long outcomes that contain a large number of different elements: • Describe the structure and function of plants, referring to transport in plants, reproduction, seed structure, germination, growth and development and plant adaptations within the context of a range of different ecosystems	☒
Don't write learning outcomes that are at too general a level • Be creative • Understand the principles of vectors • Master concepts related to 'force'	☒
Don't only write learning outcomes that are at the lower levels of cognitive thinking • Describe, understand, recall, recognise, illustrate, define, name, state…	☒

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