

Learning Outcomes in Mechanical Engineering Results of the 2016 Survey

Section de Génie mécanique

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1. Introduction

What is a learning outcome?

A learning outcome is "a clear statement of what successful students will be able to do at the end of a course".¹

Learning outcomes in mechanical engineering at EPFL

SGM was the first section at EPFL to adopt learning outcomes. Learning outcomes were identified and defined as a result of a 2-year (2009-2010) pilot project, partly supported by the Rectors' Conference of the Swiss Universities (CRUS), that involved ME teachers, industrial partners and a team of pedagogists². The final output of the project consisted of seven lists of learning outcomes; one for each ME concentration and a list of transversal skills. Learning outcomes were first introduced in course descriptions in 2011-2012. In 2013-2014, with the introduction of learning outcomes for the whole EPFL, for the sake of uniformity, SGM decided to adopt the transversal learning outcomes defined at the School level instead of its own (the differences between the two sets were not essential).

Objective of the survey

Curricula, especially in engineering, have to evolve by making room to up-to-date knowledge and technology and by abandoning content that is becoming obsolete. As a consequence, SGM teachers work to continuously improve the content of their courses and the respective learning outcomes. This work done within the walls of EPFL needs to be periodically assessed by external partners, who have direct experience of the quality of the education offered by SGM.

The introduction of mandatory internships in 2013/14 provided SGM with a valuable tool to obtain "quasi real-time" information about employer satisfaction, since it is reasonable to assume that the level of satisfaction in the case of an internship is representative of that of an actual job. Of the ME students who did internships over the last few years, the large majority were considered by their supervisors "excellent" or "good".

Although internships are a valuable tool, in 2016, about six years after the end of the aforementioned pilot project, SGM teachers felt the need for a formal evaluation and validation of the learning outcomes offered in the Bachelor and Master programs, by means of survey addressed to industrial partners and alumni.

The results of the survey, summarized in this report, are being and will be used to improve the study plans to better prepare mechanical engineering students for today's and tomorrow's challenges.

¹from the website of EPFL's Teaching support centre (CAPE) <http://cape.epfl.ch/faq-learning-outcomes>

²Projet Compétences SGM - Rapport d'activité de la collaboration EPFL-UNIFR, mai 2009 - avril 2010

2. Methodology

The survey was run in summer 2016, and was realised by using GoogleForms¹. The survey invitees were contacted by email by SGM Director. The first phase (10 June - 15 July) saw the participation of the supervisors (158 invitees) of the mandatory internships of ME students during the last two academic years; in the second phase (18 July - 31 August) the invitation was extended to alumni (1232 invitees).

2.1 The Survey

The survey consisted of three sections: the first two allowed collecting basic information about the participant and the company he/she works or was working for; the third section was dedicated to the actual assessment of learning outcomes.

2.1.1 Personal and professional information

1. Education

- EPFL or ETHZ diploma in Mechanical Engineering
- EPFL or ETHZ diploma in a program other than Mechanical Engineering
- Diploma in Mechanical Engineering from a university other than EPFL or ETHZ
- Diploma in a program other than Mechanical Engineering from a university other than EPFL or ETHZ
- Diploma from an HES
- Other

2. Age?

- <30
- 30-39
- 40-49
- >49

3. What is your function?²

- Administrative
- Technical
- Managerial
- Other

4. Which of the Mechanical Engineering concentrations offered at EPFL is closer to your job?

- Aero-Hydrodynamics
- Controls and Mechatronics
- Biomechanics
- Design and Production
- Energy
- Solids and Structures
- None of these

5. In which country are you working?

¹<https://www.google.ch/intl/en/forms/about/>

²If the participant was not working at the time of the survey, he/she could refer to his/her last job.

2.1.2 Information about the company you are working for

1. Number of employees

- >5000
- 250-5000
- 10-249
- <10
- Other

2. Domain of activity

- Mechanical Engineering (e.g. energy, transportation, mechatronics, watch industry, etc.)
- In a domain other than Mechanical Engineering, which has nevertheless an important Mechanical Engineering component (e.g. food industry, biomedical, home appliances, etc.)
- In a domain other than Mechanical Engineering (e.g. education, finance, real estate, etc.)

3. Legal status

- Privately owned enterprise
- State-owned Enterprise
- Hybrid (partially state-owned)
- Other

2.1.3 Assessment of learning outcomes

In this section of the survey, the participant had the opportunity to assess the learning outcomes of one or more Mechanical Engineering concentrations (Aero-Hydrodynamics, Controls and Mechatronics, Biomechanics, Design and Production, Energy, Solids and Structures) as well as the transversal (soft) skills. He/she was asked to assess the importance of each learning outcome by choosing one of the following three options:

- Not necessary
- Nice to have
- Essential

Moreover, he/she was also asked to indicate additional learning outcomes that should be included in the list.

3. Results

The survey was well received: the response rates were 20% (35 out of 176) for internship supervisors and 39% (476 out of 1232) for alumni. A first analysis of the results lead to the conclusion that the differences between the responses of the two populations are negligible; therefore only the alumni's responses are presented in this report.

3.1 The participants

The responses to questions about the participants are summarized in figure 3.1 (since only alumni are considered, data about education is not reported). The four age groups are well represented (a): <30 and >49 are around 25% while 30-39 and 40-49 are at 31.7% and 18.3%, respectively. Participants are equally distributed between managerial (44.7%) and technical (42.2%) functions (b), and the great majority of them (76.7%) works in Switzerland (d). For what concerns the domain of activity (c), 77.2% of the participants work in a domain close to one of the mechanical engineering concentrations offered at EPFL and about one third of them in Design and Production. Only 3.6% of the alumni are active in Biomechanics, a domain which is much younger than the other five.

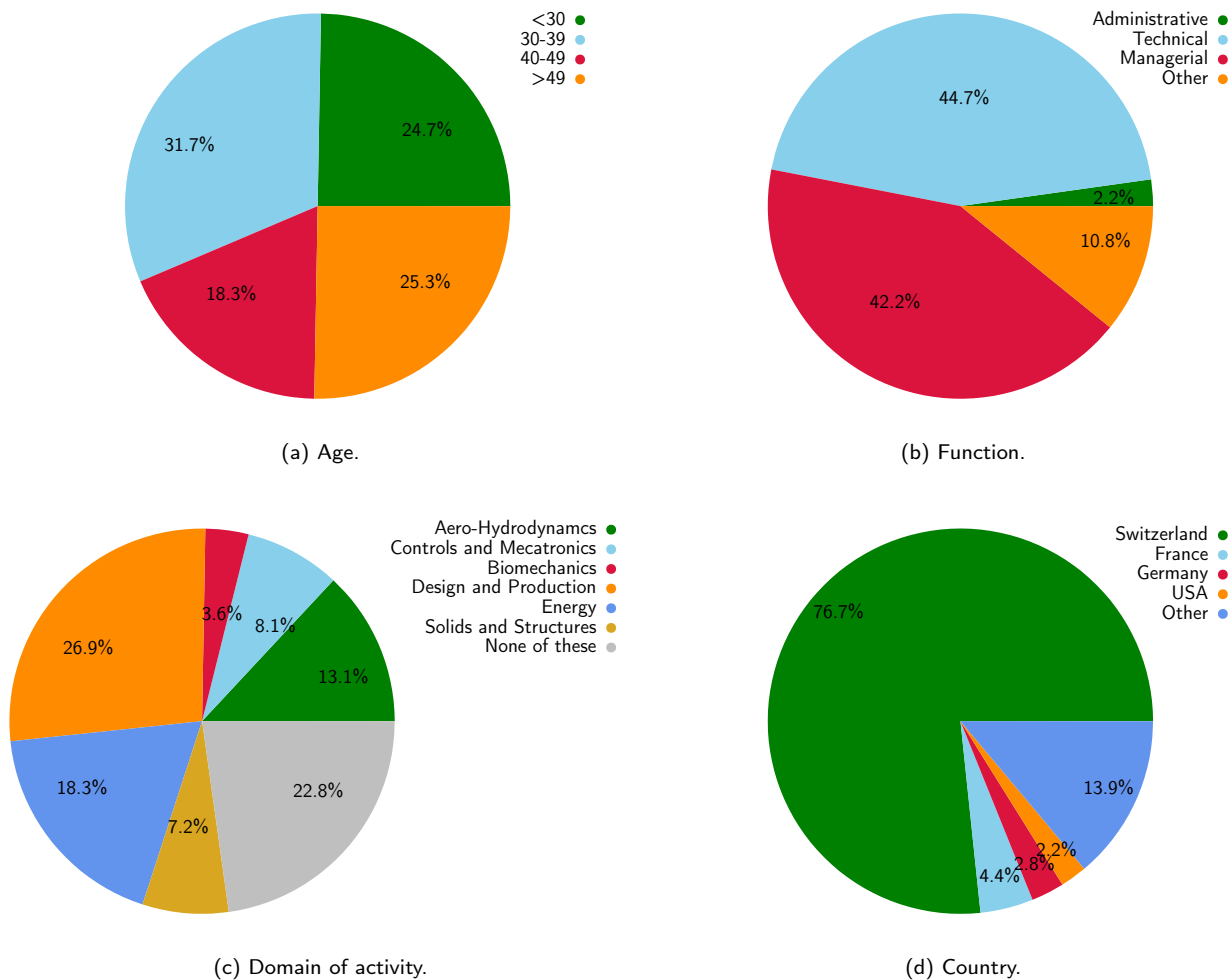


Figure 3.1: Summary of the information about participants.

3.2 The companies

The alumni's responses about the companies they are working for are presented in figure 3.2. Size-wise (a), companies are distributed evenly among large (more than 5000 employees, 34.2%), intermediate-sized (between 250 and 5000 employees, 29.2%) et small and medium-sized (between 10 et 249 employees, 26.7%); 8.3% of the participants work for microenterprises (less than 10 employees). About half (52.8%) of these companies are active in the Mechanical Engineering domain, and almost a quarter (23.9%) in a domain other than Mechanical Engineering, which has nevertheless an important Mechanical Engineering component other than Mechanical Engineering (b). The great majority (70.8%) of alumni work in the private sector (c), as it could be expected.

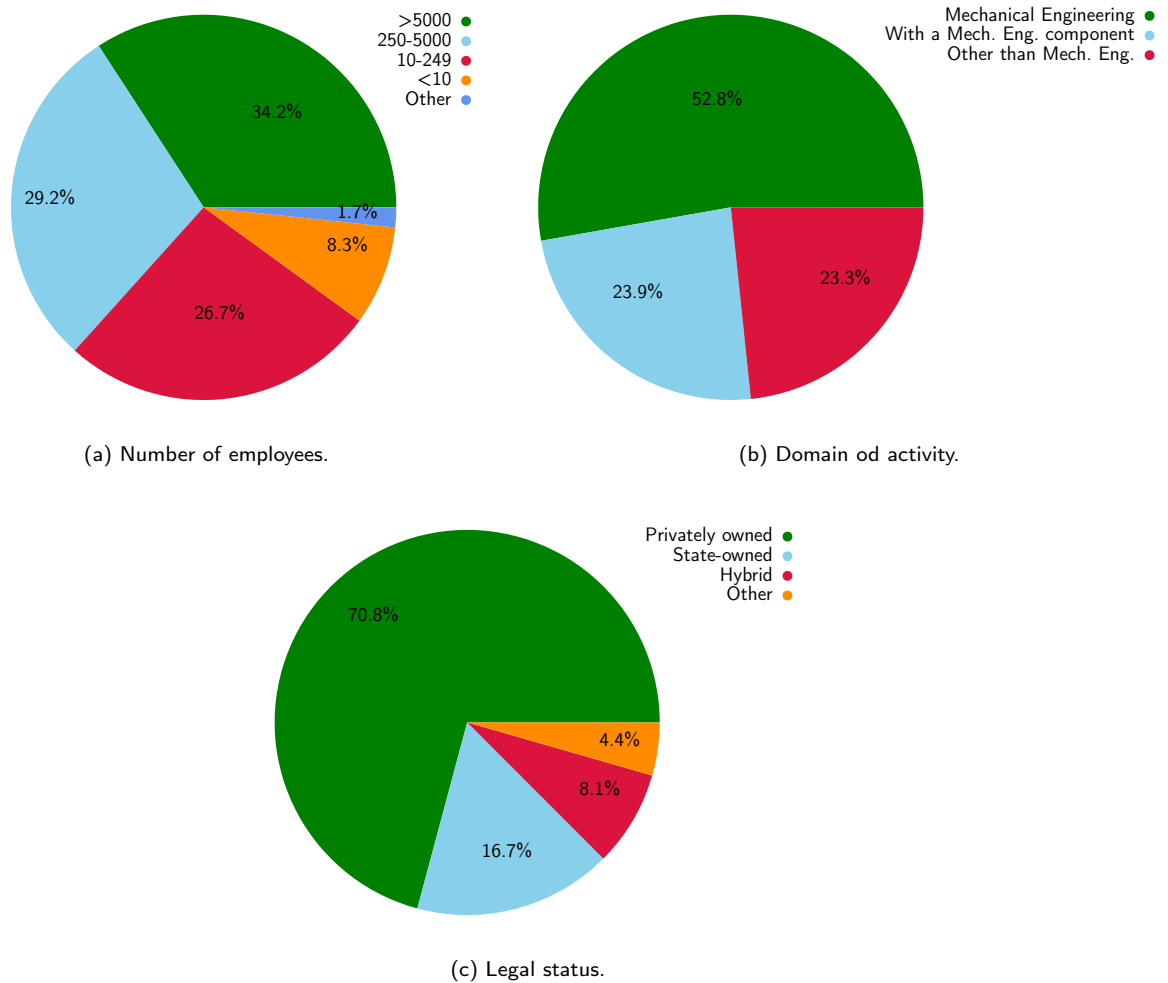


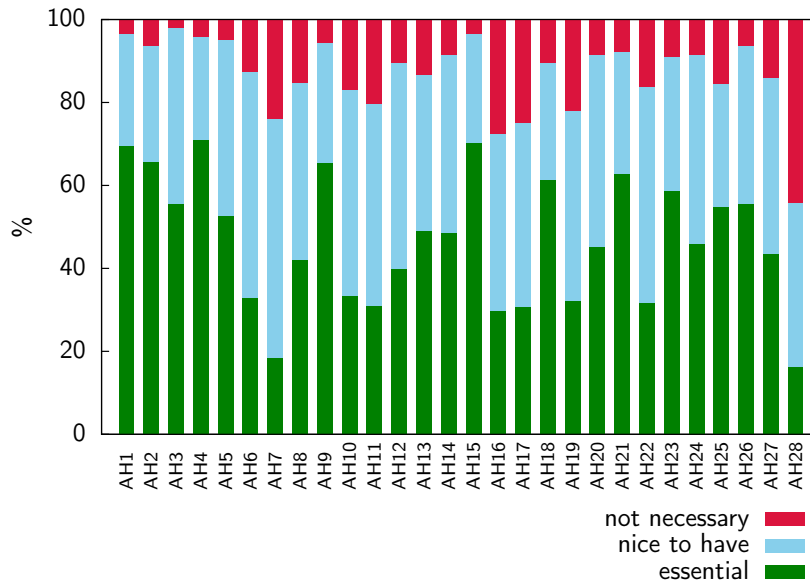
Figure 3.2: Synthetic representation of the responses to questions about the companies SGM alumni work for.

3.3 Assessment of the learning outcomes

This section presents with a series of histograms the results of the assessment of the learning outcomes of each concentration. The most frequent comments about learning outcomes that could be introduced in the curriculum are reported as well.

3.3.1 Aero-Hydrodynamics (143 responses)

Importance of learning outcomes



- AH1 Describe the physical behaviour of a flow in scientific terms
- AH2 Link flow behaviour with non-dimensional parameters (e.g. Reynolds and Mach numbers)
- AH3 Describe physical phenomena associated with compressibility; determine if a given flow can be treated as incompressible
- AH4 Describe the physical differences between laminar and turbulent flows
- AH5 Describe in detail the physical phenomena associated with the interaction of a flow with a solid wall (as a function of its characteristics, e.g. roughness)
- AH6 Describe hydrodynamic instabilities in laminar, incompressible flows; explain the physical phenomena associated with the transition to turbulence
- AH7 Describe the different types of non-Newtonian flows and provide examples of both Newtonian and non-Newtonian flows
- AH8 Describe cavitation and its consequences in physical terms; predict the appearance of cavitation pockets in the flow
- AH9 Describe flow in simple geometries, such as over a flat plate, in a tube, or around a sphere or airfoil
- AH10 Determine the flight characteristics from a wing shape and choose a wing shape to provide the desired flight characteristics
- AH11 Describe 3D effects resulting, for example, from a finite wing span or behind a blunt body
- AH12 Analyze the flow in water and gas turbines; know how to dimension the important elements of turbomachinery
- AH13 State the conserved quantities in a given flow and link them to a physical-mathematical description
- AH14 Define, describe and apply the basic flow equations, such as the Navier-Stokes equations
- AH15 Describe simplified governing equations, such as the Bernoulli or potential equations, their domain of validity and apply them in appropriate situations
- AH16 Describe the difference between the Eulerian and Lagrangian approaches
- AH17 Obtain by an order of magnitude analysis, the simplified equations describing lubrication and boundary layers
- AH18 Identify and apply the different steps in a numerical simulation (e.g. geometry and mesh generation, computation, post-processing) and integrate all the essential basic concepts in a numerical flow simulation
- AH19 Resolve analytically or numerically the potential flow around an airfoil
- AH20 Evaluate numerical accuracy as a function of the choice of simulation parameters
- AH21 Analyse numerical solutions and identify any inconsistencies with respect to physical reality; understand and apply the concepts of verification and validation
- AH22 Describe different methods used to discretize differential equations, such as finite differences, finite elements, finite volumes, lattice Boltzmann, SPH
- AH23 Understand similarity laws and their use for dimensioning an experimental testbed
- AH24 Describe the techniques used to measure physical flow quantities; choose the appropriate technique to measure to a desired accuracy
- AH25 Understand the basics of computer programming; develop a (simple) structures software using a programming

language / environment such as C, Fortran or Matlab

AH26 Perform a numerical simulation with appropriate software; understand the limits of each software in terms of its application domain and accuracy of the results obtained

AH27 Choose the appropriate turbulence model for a given turbulent flow

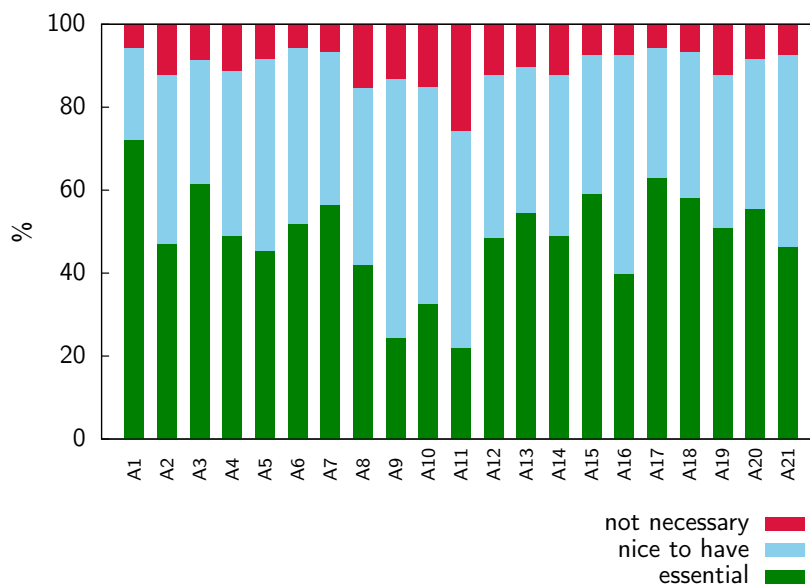
AH28 Estimate relevant length- and timescales of turbulent flows based on Kolmogorov theory

Learning outcomes to be included in the curriculum

- Fluid-structure interaction
- Basic notions in numerical methods (essential to use commercial software)
- Microfluidics
- Non-newtonian fluids

3.3.2 Controls and Mechatronics (108 responses)

Importance of learning outcomes



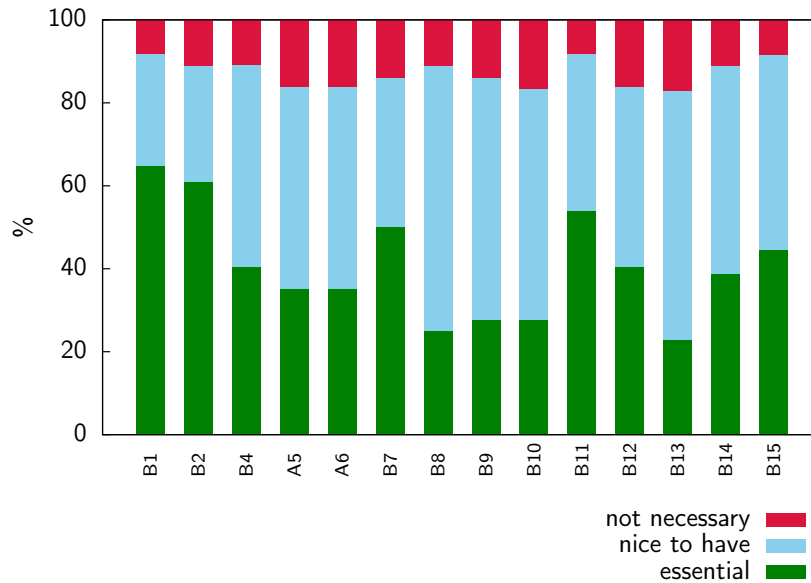
- A1 Represent a physical process as a system with its inputs, outputs and disturbances and derive its dynamic equations
- A2 Linearize a nonlinear system
- A3 Analyze a linear dynamical system (both time and frequency responses)
- A4 Represent a system by a transfer function and by a linear or nonlinear state-space model
- A5 Construct and analyse a discrete-time model for a dynamic system
- A6 Identify a dynamic system using experimental data
- A7 Design a PID controller
- A8 Design a simple controller for a dynamic system
- A9 Analyse a nonlinear dynamic system and design a linear or nonlinear controller for the system
- A10 Analyse a multivariable dynamic system and design an appropriate controller for the system
- A11 Design an advanced controller for a dynamic system
- A12 Assess the stability, performance and robustness of a closed-loop system
- A13 Define (specifications) the adequate control performance for dynamic systems
- A14 Propose several control solutions, formulate the trade-offs, choose the options
- A15 Explain the operation of sensors, actuators and of the respective control algorithms
- A16 Instrument a dynamic system to determine its behaviour
- A17 Formulate the specifications of a mechatronic system
- A18 Define (specifications) the control performance for mechatronic systems
- A19 Justify methodological choices and validate the results with respect to the specifications
- A20 Design mechatronic systems (choice of sensors, actuators, embedded systems)
- A21 Validate the performance (by simulations or experiments) of a mechatronic system

Learning outcomes to be included in the curriculum

- PLC (Programmable Logic Controller) programming
- Simulation of dynamical systems

3.3.3 Biomechanics (37 responses)

Importance of learning outcomes



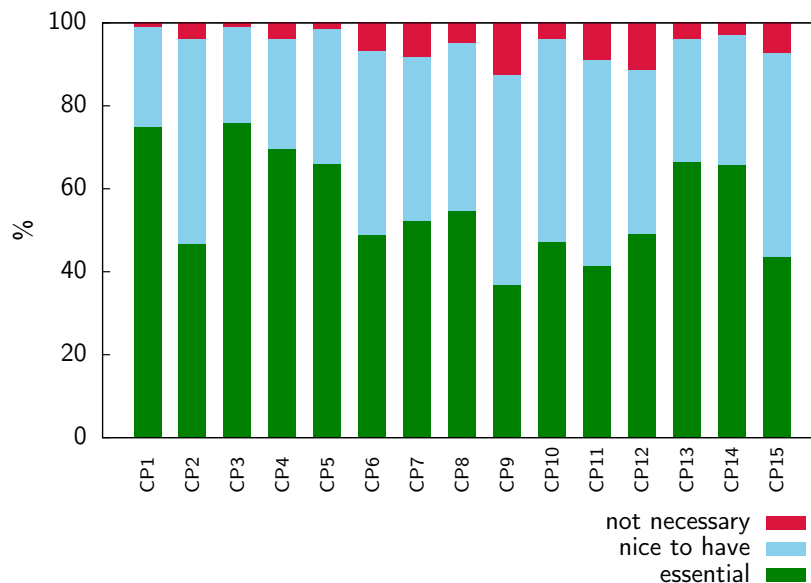
- B1 Describe the biomechanical function of different tissues that are found in the human body
- B2 Explain the link between the physiology and the mechanical properties of a tissue
- B3 Calculate the kinematics and the forces in articulations
- B4 Compute shear stresses in blood in particular flow conditions
- B5 Identify the mechanical behaviour of tissues and fluids from experimental data
- B6 Propose mechanical tests for the characterization of biologic tissues and fluids
- B7 Be able to compare the range of validity of different constitutive laws
- B8 Implement a constitutive law in a simulation software
- B9 Describe the feedback loop that, starting from a mechanical signal translated into a chemical signal, allows for the adaptation of the mechanical properties of tissues
- B10 Compute the stresses and strains at the interface of an implant and in the surrounding tissues
- B11 Compute the kinematics and forces in an implant
- B12 Assess the mechanical properties during the degradation of a bioresorbable implant
- B13 Illustrate the effects of storage techniques on the mechanical properties of a tissue
- B14 Describe the procedure to identify a constitutive law
- B15 List and explain the hygiene and safety rules applicable to biomechanical testing of biologic tissues

Learning outcomes to be included in the curriculum

- Know the regulations and quality certification procedures of the pharmaceutical and medical industries

3.3.4 Design and Production (208 responses)

Importance of learning outcomes



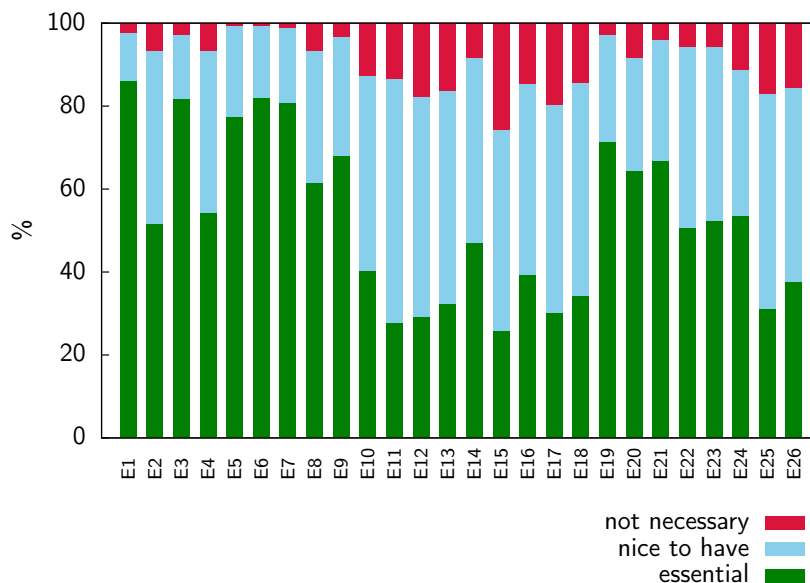
- CP1 Choose suitable methods and tools for the development of, the modelling and simulation of, the analysis of and the choice of solution for an engineering problem in the mechanical engineering domain (product design, manufacturing process and system production)
- CP2 Use experimental and numerical analysis tools with ease and fluency
- CP3 Analyse design requirements to define and quantify the engineering specifications
- CP4 List, define, and quantify the functions of an existing or new design based on the engineering specifications
- CP5 Select the main design solution based on the required functional components and other quantifiable design parameters (i.e. mechanical performance, manufacturing costs, development time, available technology)
- CP6 Model the defined problem based on the geometric, kinematic / dynamic, material assumptions while choosing suitable numerical and analytical tools followed by the experimental validation
- CP7 Realize, analyse and optimize a model: 3D complex geometries and assemblies, static, kinematic, dynamic, thermal and ultimate behaviour, life-cycle and costs of a system (product, manufacturing process or production system)
- CP8 Choose production tools and methods based on performance and cost requirements and needs, taking into consideration applicability limits and associated hypotheses
- CP9 Model, analyse and optimize the internal logistics of a production and distribution system and the dynamic behaviour of a network of companies
- CP10 Design a system based on engineering specifications utilizing suitable numerical and analytical tools for optimizing the design parameters
- CP11 Identify the main- and sub-functions of a mechanical system and corresponding main- and sub-systems in a complete mechanical system / machine to classify the required constitutive elements
- CP12 Illustrate the physical principles of production processes features and limits of production processes
- CP13 Learn, implement and apply project management, budget, technical report, resource management skills
- CP14 Apply, adapt and synthesize learned engineering skills to create novel solutions
- CP15 Expand and iterate multiple design concepts based on the models and simulations.

Learning outcomes to be included in the curriculum

- Project management
- Six sigma, lean et agile techniques
- Ability to choose the materials that can comply with technical and financial requirements
- Financial analysis (production systems, products, projects)
- Notions of quality
- Machine elements

3.3.5 Energy (181 responses)

Importance of learning outcomes



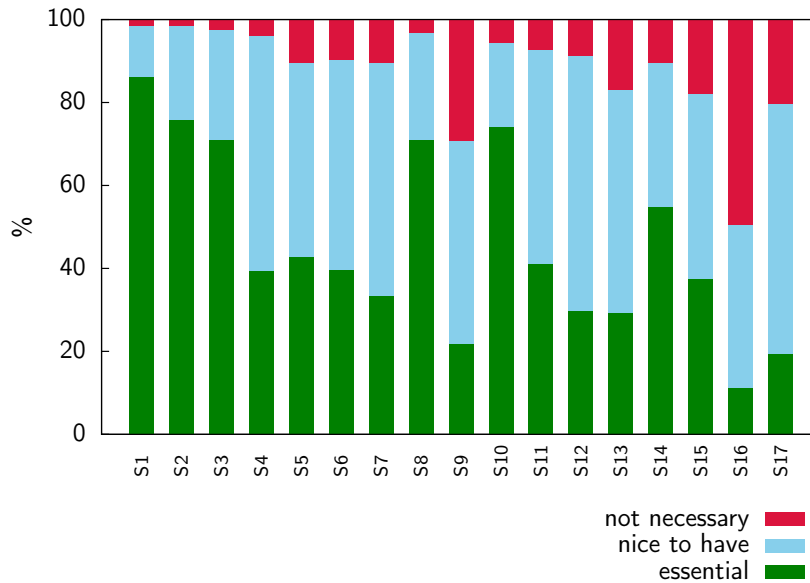
- E1 Explain and apply the concepts of mass, energy, and momentum balance
- E2 Compute the thermodynamic properties of a fluid
- E3 Explain and apply the concepts of heat and mass transfer
- E4 Compute the main thermodynamic transformations of compressible and incompressible fluids
- E5 Describe and explain the main thermodynamic cycles
- E6 Explain and apply the concepts of thermodynamic efficiency
- E7 Explain the principles and limitations of the main energy conversion technologies
- E8 Characterize fossil and renewable energy resources and their corresponding conversion technologies
- E9 Understand the challenges related to energy: resources, energy services, economic and environmental impacts
- E10 Calculate fluid flows in energy conversion systems, compute pressure drops and heat losses and fluid-structure interactions
- E11 Select materials for energy conversion systems based on fluids and operating conditions
- E12 Calculate and design hydraulic machines
- E13 Calculate and design dynamic and volumetric compressors and turbines
- E14 Calculate and design heat exchangers
- E15 Calculate and design internal combustion engines
- E16 Calculate and design solar collectors and receivers
- E17 Calculate and design wind power plants
- E18 Calculate and design thermo-chemical (boilers, gasification) and thermo-electric (fuel cells) conversion units
- E19 Explain and apply the concepts of energy storage (heat, electricity, inertia)
- E20 Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance
- E21 Analyse the energy and exergy efficiency of industrial energy systems
- E22 Model, design and optimize energy conversion systems and industrial processes
- E23 Explain and calculate the main emission sources of energy conversion processes
- E24 Measure the temperature, pressure, flow and composition of a fluid
- E25 Design a measurement set-up for an energy conversion system
- E26 Experimentally characterize the operation of an energy conversion system, establish an experimental plan and identify the parameters of a model

Learning outcomes to be included in the curriculum

- Financial aspects, profitability comparison, energy market
- Aspects related to the safety of plants
- Strategies et policies for the reduction of CO2 emissions

3.3.6 Solids and structures (124 responses)

Importance of learning outcomes



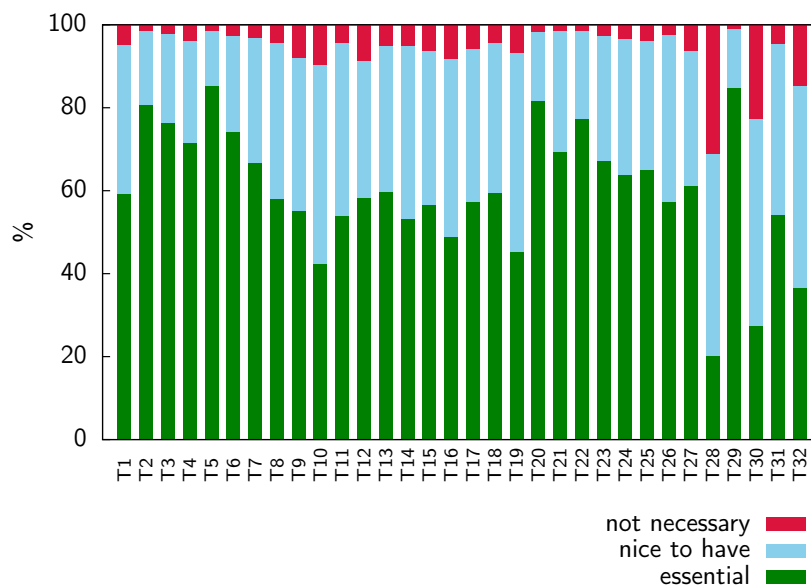
- S1 Model and analytically solve simple problems of statics and stress analysis
- S2 Analyse and design assemblies of simple mechanical elements in the framework of static and buckling
- S3 Predict and optimize the vibration behaviour of multiple-degree-of-freedom or continuum systems
- S4 Carry out an experimental modal analysis of a real structure
- S5 Identify the constitutive behaviour of a material from the results of a mechanical test and choose a suitable test standard
- S6 Evaluate the performance of different classes of composite materials as well as the production processes
- S7 Apply the models for the behaviour of composite materials to compute the response of simple composite structures
- S8 Apply the principles of damage, fatigue and fracture mechanics to analyse and design real structures
- S9 Derive a finite element formulation from the differential equations in strong form
- S10 Apply the finite element method to realize a complete study of a real problem
- S11 Characterize experimentally the steady-state or dynamic response of solids, fluids
- S12 Model with analytical or numerical tools the nonlinear response of structures and materials
- S13 Describe in scientific terms and apply the principles of tribology and contact mechanics
- S14 Formulate and solve a problem of numerical structural dynamics corresponding to a real case
- S15 Apply an appropriate numerical method for multiphysics simulations to a complex physics problem
- S16 Describe in scientific terms and apply the classical theory of aeroelasticity of slender wings
- S17 Illustrate the principles and limitations of the techniques to model fluid-structure interactions in numerical simulations

Learning outcomes to be included in the curriculum

- Mechanical properties of materials
- Fatigue
- Understand the limits of finite elements

3.3.7 Transversal skills (290 responses)

Importance of learning outcomes



- T1 Assess progress against the plan, and adapt the plan as appropriate
- T2 Set objectives and design an action plan to reach those objectives
- T3 Plan and carry out activities in a way which makes optimal use of available time and other resources
- T4 Use a work methodology appropriate to the task
- T5 Communicate effectively, being understood, including across different languages and cultures
- T6 Communicate effectively with professionals from other disciplines
- T7 Give feedback (critique) in an appropriate fashion
- T8 Evaluate one's own performance in the team, receive and respond appropriately to feedback
- T9 Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles
- T10 Keep appropriate documentation for group meetings
- T11 Negotiate effectively within the group
- T12 Chair a meeting to achieve a particular agenda, maximising participation
- T13 Resolve conflicts in ways that are productive for the task and the people concerned
- T14 Take account of the social and human dimensions of the engineering profession
- T15 Respect relevant legal guidelines and ethical codes for the profession
- T16 Respect the rules of the institution in which you are working
- T17 Take responsibility for health and safety of self and others in a working context
- T18 Take responsibility for environmental impacts of her/ his actions and decisions
- T19 Assess one's own level of skill acquisition, and plan their on-going learning goals
- T20 Demonstrate the capacity for critical thinking
- T21 Demonstrate a capacity for creativity
- T22 Manage priorities
- T23 Continue to work through difficulties or initial failure to find optimal solutions
- T24 Take feedback (critique) and respond in an appropriate manner
- T25 Use both general and domain specific IT resources and tools
- T26 Access and evaluate appropriate sources of information
- T27 Write a scientific or technical report
- T28 Write a literature review which assesses the state of the art
- T29 Make an oral presentation
- T30 Design and present a poster
- T31 Collect data
- T32 Summarize an article or a technical report

Learning outcomes to be included in the curriculum

- Financial and economical in project and enterprise management
- HR skills
- Team management
- Knowledge of languages

- Legal and certification aspects
- Relational aspects
- Risk analysis

3.3.8 Discussion

All the learning outcomes are considered "essential" or "nice to have" by the majority of the participants. This results is a clear sign that the curriculum is generally appreciated. Nevertheless, it is useful to analyse the learning outcomes that received the worse evaluations ($\geq 20\%$ "not necessary") as well as those whose introduction in the study plan was suggested. The following learning outcomes were considered "not necessary" by more than 20% of the participants:

- AH11 Describe 3D effects resulting, for example, from a finite wing span or behind a blunt body
- AH16 Describe the difference between the Eulerian and Lagrangian approaches
- AH17 Obtain by an order of magnitude analysis, the simplified equations describing lubrication and boundary layers
- AH19 Resolve analytically or numerically the potential flow around an airfoil
- AH28 Estimate relevant length- and timescales of turbulent flows based on Kolmogorov theory
- A11 Design an advanced controller for a dynamic system
- E15 Calculate and design internal combustion engines
- S9 Derive a finite element formulation from the differential equations in strong form
- S16 Describe in scientific terms and apply the classical theory of aeroelasticity of slender wings
- S17 Illustrate the principles and limitations of the techniques to model fluid-structure interactions in numerical simulations
- T28 Write a literature review which assesses the state of the art
- T30 Design and present a poster

SGM identified different reasons for the relatively low score obtained by the aforementioned learning outcomes:

- Learning outcomes listed in the "wrong" concentration: S16 and S17 are about fluid-structure interaction and are included in the "Solids and Structures" concentration. The survey indicates that they are of marginal importance in "Solids and Structures" but should be included in aero-hydrodynamics.
- Learning outcomes written in a too abstract or "excessively academic" manner: AH16, AH17, AH28 and S9 cover fundamental theoretical knowledge in solid and fluid mechanics and are required for applications. They would be appreciated if stated in a different fashion (e. g. AH 27 and AH28 could be combined in one learning outcome "Analyse and model turbulent flows" and S9 could be reformulated as follows: "Illustrate fundamental aspects of finite element modeling techniques").
- Learning outcomes that are too specific: AH11 et A11 formulated in a very detailed manner and could be made more general if combined with other learning outcomes (e. g. A11 and A8 could become one learning outcome: "Design a controller for a dynamic system").
- Learning outcomes related to domains that are not major industrial sectors in Switzerland and in particular in the French-speaking part of Switzerland, such as E15 that is about internal combustion engines. Note that the score of other learning outcomes suffer for the same reason (e. g. AH11, AH19 et S16, which are related to the aerospace domain).
- Learning outcomes that are useful in academia but not fundamental in industry: T28 and T29. Nevertheless, it can be noted that T28 could be reformulated as: "Assess the state of the art".

SGM also categorized the "Learning outcomes to be included in the curriculum" proposed by its alumni:

- Learning outcomes that are already offered by the curriculum but are not explicitly mentioned in the lists or are listed in a concentration other than that considered by the survey participant (e. g. "Basic notions in numerical methods", "Machine elements" et "Mechanical properties of materials").
- Learning outcomes that are covered by courses taught in other EPFL undergraduate or doctoral programs, as "PLC programming" and "Microfluidics".
- Learning outcomes that are taught by EPFL College of Management, such as "Project management", "Six sigma, lean et agile methods".
- Learning outcomes that would require the introduction of new courses or new modules in existing courses in Mechanical Engineering, typically "Non-Newtonian fluids", "Fatigue", and "Strategies et policies for the reduction of CO2 emissions".
- Learning outcomes that could be offered in the framework of the SHS (Social and Human Science) program: "Team management", "HR skills", "Knowledge of languages", and "Legal and certification aspects".
- Learning outcomes whose introduction in a course would be difficult but that can be part of the learning experience of the mandatory engineering internship, such as "notions of quality" and "relational aspects".

4. Action plan

4.1 Learning outcomes

The results of the survey indicate that the lists of learning outcomes need improvement. SGM plans to finalize the reviewed lists during the 2017-18 academic year, and to integrate the new learning outcomes in the course descriptions of the following academic year. The revision will aim at:

- Formulating shorter and less "academic" learning outcomes (less specific and more application-oriented).
- Reducing the overall number of learning outcomes (for example by combining corresponding theoretical and applied learning outcomes).
- Adopting the same framework for all concentrations (number of learning outcomes, length, etc.).
- Introducing new learning outcomes in compliance with the results of the survey and the appointments of new professors.

4.2 Curriculum

SGM intends to introduce in the study plan the courses currently offered in other programs that satisfy the needs highlighted in the "Learning outcomes to be included in the curriculum" section of the survey. This will be done in coordination with other sections and taking into account the academic constraints (schedule, courses reserved to certain categories of students, etc.) and the availability of resources. The objective is to integrate these new courses in the 2018-2019 study plan.

SGM will ask its teachers, and in particular new professors, to consider the outcome of the survey when proposing new courses at the master level. The objective is to progressively introduce in the curriculum the learning outcomes that are not offered as of today (for example "Non-Newtonian fluids" and "Fatigue"). This strategy should allow SGM to satisfy this demand in 2-3 years.

SGM is also actively participating in the discussions around the SHS program and will continue (as it did in the past) to ask for the introduction of SHS courses that provide students with learning outcomes that are directly applicable in the professional world (including team management skills, RH competencies, notions of intellectual property, etc.).

In order to improve the acquisition of learning outcomes during the engineering internships, SGM has decided to raise the awareness of internship supervisors by sending them at the beginning of the internship an email with a hyperlink to the evaluation form that they will have to fill in at the end of the internship. Internship supervisors are asked to assess not only the technical competence of the student, but also the following soft-skill related aspects:

- Planning and management of work tasks: definition of work objectives and management of priorities; evaluation of resources required; work planning, monitoring of activities, and management of emergent issues.
- Integration in the professional world: respect for the organizations procedures/ rules and for their profession's ethical codes; capacity to work in teams; written communication (structure, clarity, coherence of reasoning); oral communication (clarity, reasoning, self-confidence); interpersonal skills and engagement, including in a multicultural context.
- Independence: ability to present and defend her/his own ideas; capacity to access sources of information and to evaluate them; capacity to self-evaluate and to respond constructively to feedback.

4.3 Dissemination activity

This survey raised the interest of EPFL Teaching Support Centre as well as of other sections, which would like to do a similar approach. Of course SGM is more than willing to share its experience.